Lexical Functional Grammar

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Working draft, second edition.
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First edition published by Academic Press, 2001
Syntax and Semantics Series, Volume 34

March 24, 2018

CONTENTS

LIST OF ABBREVIATIONS

We have modified the glosses from our source materials for consistency with the Leipzig Glossing Rules (Bickel et al. 2015), a simplified version of which we use throughout the book. We use the following abbreviations:

1	first person
2	second person
3	third person
ABS	absolutive
ACC	accusative
ACTIVE	active
AV	active voice
AUX	auxiliary
B	Chechen gender class B
CAUS	causative
COMP	complementizer
D	Chechen gender class D
DV	dative voice
EN	Catalan *en*
ERG	ergative
EXCL	exclusive
F	feminine
FV	final vowel
FUT	future
GEN	genitive
HI	Catalan *hi*
IPRF	imperfect
INCL	inclusive
INDF	indefinite
INF	infinitive
IV	instrumental voice
LINK	Tagalog linker
LOC	locative
M	masculine
N	neuter
NOM	nominative
NFUT	nonfuture
NPST	nonpast
NONPL	nonplural
NONSG	nonsingular
OV	objective voice
PASS	passive
PST	past
PFV	perfective
PRF	perfect
PL	plural
POSTNEG	postnegation

POT	potential
PREP	preposition
PRS	present
Q	question particle
REFL	reflexive
SCV	Chechen simultaneous converb
SG	singular
VM	Hungarian verbal modifier
WP	Chechen witnessed past

PREFACE TO THE FIRST EDITION

This book is a tribute to the extraordinary accomplishments of Joan Bresnan and Ron Kaplan, my teachers, mentors, and friends. What is presented here is the theory they created together; it is lucky for all of us that they happened to end up in Pisa together back in 1977!

My first exposure to LFG was in a class taught by K.P. Mohanan at the University of Texas in 1981. Mohanan's teaching skills are legendary, and I'm grateful for having had such a good introduction to the theory.

My debt to colleagues and friends in writing this book is enormous. Tracy Holloway King assisted in every aspect of preparation of this book, from reading early and virtually unreadable drafts to providing sage advice and counsel on all aspects of the linguistic analyses presented here. I am also very grateful to the many linguists who provided helpful comments and criticism of early and late drafts of the book: Farrell Ackerman, David Ahn, Ash Asudeh, Martin van den Berg, Sascha Brawer, Joan Bresnan, Miriam Butt, Cleo Condoravdi, Dick Crouch, Chris Culy, Yehuda Falk, Brent Fitzgerald, Ken Forbus, Anette Frank, John Fry, Ron Kaplan, Shin-Sook Kim, Jonas Kuhn, John Lamping, Hiroshi Masuichi, Umarani Pappuswamy, Jonathan Reichenthal, Louisa Sadler, Ida Toivonen, Vijay Saraswat, and Annie Zaenen. Particular thanks go to colleagues who gave especially detailed and helpful comments, often on very short notice: worthy of special mention are Farrell Ackerman, Ash Asudeh, Martin van den Berg, Cleo Condoravdi, Chris Culy, Brent Fitzgerald, Yehuda Falk, Anette Frank, Ron Kaplan, Tracy Holloway King, Louisa Sadler, and Annie Zaenen. My sister Matty Dalrymple provided expert editing assistance, for which I am always grateful, and Jeanette Figueroa provided invaluable technical support.

I have also benefited from expert comments on particular chapters of the book; the range of topics covered in this book far exceeds anything I could have attempted unaided. Ron Kaplan provided assistance with Chapter 2 (Functional Structure), Chapter 5 (Describing Syntactic Structures), and Chapter 6 (Syntactic Relations and Syntactic Constraints); Tracy Holloway King assisted with Chapter 3 (Constituent Structure); Farrell Ackerman and Miriam Butt assisted with Chapter 9 (Argument Structure and Mapping Theory); Ash Asudeh, Martin van den Berg, Dick Crouch, and Tracy Holloway King assisted with Chapter 8 (Meaning and Semantic Composition); Cleo Condoravdi assisted with Chapter 13 (Modification); Martin van den Berg, Dick Crouch, John Lamping, Louisa Sadler, and Annie Zaenen assisted with Chapter 14 (Anaphora); Ash Asudeh, Cleo Condoravdi, Dick Crouch, and Tracy Holloway King assisted with Chapter 15 (Functional and Anaphoric Control); Chris Culy assisted with Chapter 16 (Coordination); and Ash Asudeh, Martin van den Berg, Cleo Condoravdi, Dick Crouch, Stanley Peters, Tracy Holloway King, and Annie Zaenen assisted with Chapter 17 (Long-Distance Dependencies). Besides help with particular chapters, I owe an enormous intellectual debt to colleagues whose clear thinking and unerring formal intuitions are evident on each page of this book: Ron Kaplan, John Lamping, John Maxwell, Fernando Pereira, and Vijay Saraswat.

Ken and David Kahn also deserve thanks for putting up with me as this book took shape, and for enriching my life beyond measure.

Two other books on LFG have recently appeared: Joan Bresnan's *Lexical-Functional Syntax* and Yehuda Falk's *Lexical-Functional Grammar: An Introduction to Parallel Constraint-Based Syntax*. These valuable resources are intended for use as textbooks and contain exercises and guidance for using the books as teaching material; Falk's book also contains a useful glossary of terms. This book contrasts with Bresnan's and Falk's in several ways: it is not intended primarily as a textbook but rather as a handbook and theoretical overview, and it includes semantic as well as syntactic analyses of the linguistic phenomena that are discussed. Each book fills a different need in the community; it is a happy confluence of factors that produced all of these LFG resources within a relatively brief period.

Although much has had to be omitted in this work, my hope is that what has been collected here will be useful and that it will form a basis for future researchers to fill in the many gaps that remain.

PREFACE TO THE SECOND EDITION

As usual, the LFG community has been incredibly supportive of our work in producing this second edition, and we are grateful to the many people who provided comments, feedback and support. We begin by conveying our thanks to Luke Carr, Jamie Findlay, and Miltiadis Kokkonidis for helpful comments on the first edition of the book.

We would like to single out three heroic individuals for special praise for their dedication and thoroughness in reading and commenting on multiple versions of the second edition as it took shape. Bozhil Hristov, Adam Przepiórkowski, and Amanda Thomas each read through several versions of the entire book, giving valuable comments and feedback each time. We have been particularly impressed by Adam's ability to detect problems from the microscopic to the macroscopic level. We hope they will feel that the final version of the book reflects their hard work and the helpful comments and suggestions that they made.

We are also grateful to those of our readers who commented in detail on entire sections of the book. For detailed and helpful comments on the chapters in Part 1, we are grateful to Ash Asudeh, Alex Biswas, Ken Kahn, Leslie Lee, Joey Lovestrand, Agnieska Patejuk, Liselotte Snijders, and Martin Trpovski. For comments on Part 2, we are grateful to Ash Asudeh, Alex Biswas, Leslie Lee, and Joey Lovestrand.

We are also grateful to readers who provided comments on individual chapters of the book. In Part 1: Miriam Butt for Chapter 1 (Background and Theoretical Assumptions); I Wayan Arka, Agnieska Patejuk and Ida Toivonen for Chapter 2 (Functional Structure); Ida Toivonen for Chapter 3 (Constituent Structure); Oleg Belyaev and Ron Kaplan for Chapter 5 (Describing Syntactic Structures); and Ron Kaplan for particularly detailed and helpful comments on Chapter 6 (Syntactic Relations and Syntactic Constraints). In Part 2: Miriam Butt for Chapter 7 (Beyond C-Structure and F-Structure: Linguistic Representations and Relations) and Chapter 9 (Argument Structure and Mapping Theory); Aditi Lahiri for Chapter 11 (Prosodic Structure); and Alex Biswas, Miriam Butt, Louisa Sadler, and Andy Spencer for Chapter 12 (The Interface to Morphology). In Part 3: Doug Arnold, Ash Asudeh, and Andy Morrison for Chapter 13 (Modification); Dag Haug for Chapter 14 (Anaphora) and Chapter 15 (Functional and Anaphoric Control); Doug Arnold, Oleg Belyaev, Dag Haug, John Lamping, Adam Przepiórkowski, Louisa Sadler, and Vijay Saraswat for Chapter 16 (Coordination); Doug Arnold, Ash Asudeh, and Ron Kaplan for Chapter 17 (Long-Distance Dependencies); Ash Asudeh, Aaron Broadwell, Kersti Börjars, Ron Kaplan, Peter Sells, Nigel Vincent, and Andy Way for Chapter 18 (Related Research Threads and New Directions); and Liselotte Snijders for the bibliography. This book has been long in the making, and we apologize if we have omitted reference to anyone whose comments we have benefited from but who is not mentioned here.

We are also grateful to the support we have received from the Faculty of Linguistics, Philology, and Phonetics at the University of Oxford. Mary Dalrymple is grateful to the following organizations for research support: 2011–14: Ministerio de Ciencia e Innovación, Gobierno de España: 'The syntax and information structure of unbounded dependencies', principal investigator Prof. Alexandre Alsina, Universitat Pompeu Fabra, Barcelona); 2012: British Academy Small Grant 'Plural semantics in Austronesian'; 2012–13: Leverhulme Research Fellowship 'Plurals: Morphology and Semantics', RF-2012-295; 2017: Centre for Advanced Study at the Norwegian Academy of Science and Letters, 'SynSem: From Form to Meaning - Integrating Linguistics and Computing', principal investigators Prof. Dag Haug and Prof. Stephan Oepen. John Lowe is grateful to the following organizations for research support: 2012–15: Leverhulme Early Career Fellowship (ECF-2012-081); 2013–14: Ministerio de Ciencia e Innovación, Gobierno de España: 'The syntax and information structure of unbounded dependencies', principal investigator Prof. Alexandre Alsina, Universitat Pompeu Fabra, Barcelona); 2016: Jill Hart Fund for Indo-Iranian Philology, University of Oxford.

1

BACKGROUND AND THEORETICAL ASSUMPTIONS

Lexical Functional Grammar (LFG) is a nontransformational theory of linguistic structure which assumes that language is best described and modeled by parallel structures representing different facets of linguistic organization and information, related to one another by means of functional constraints.

1. HISTORICAL ROOTS

The theory had its beginnings in the 1970s, at a time of some upheaval in the theory of generative grammar. Early transformational grammar proposed the existence of "kernel sentences" (Chomsky 1957), basic simple declarative clauses generated by a simple phrase structure grammar. More complex sentences were derived from these simple sentences by various transformations: for example, passive sentences were derived from their active counterparts by means of a passive transformation, described in terms of properties of the phrase structures of the input and output sentences. The influence of the transformational view persists to the present day in the process-oriented terminology commonly used for various grammatical phenomena: wh-movement, passivization, dative shift, and so on.

In time, however, the lack of generality of the early transformational approach began to be seen as problematic. It was not easy to see how the very specific transformations that had been proposed could capture crosslinguistic generalizations. For example, as discussed by Perlmutter and Postal (1977), there seemed to be no way to give a uniform statement of transformational rules across languages with different phrase structural descriptions for obviously similar transformations such as Passive. It became increasingly clear that the generalizations underlying many transformational rules depend not on phrase structure configuration, but on traditional abstract syntactic concepts such as subject, object, and complement. If rules could be stated in terms of these abstract concepts, a crosslinguistically uniform statement of generalizations about such rules would emerge.

At the same time, it was noted that a large class of transformations were "structure preserving" (Emonds 1976, page 3):

> A transformational operation is structure-preserving if it moves, copies, or inserts a node C into some position where C can be otherwise generated by the grammar.

The existing transformational framework would not have led to the prediction that transformations would operate in this way. Since transformations were not constrained as to the output structure they produced, it was surprising that they would produce structures like those that the basic grammar could otherwise generate. This important finding had wide-reaching implications: the basic phrase structure of languages is invariant, and the application of particular transformations does not alter this basic phrase structure.

Why should so many transformations have been structure-preserving in this sense? Bresnan (1978) made the key observation: all structure-preserving transformations can be reformulated as *lexical redundancy rules*. According to this view, operations on the abstract syntactic argument structure of a lexical item produce a new syntactic argument structure, with a surface form that is realized in an expected way by a basic phrase structure grammar. This allowed an abstract and uniform crosslinguistic characterization of argument alternations like the active-passive relation, while also allowing for a theory of crosslinguistic similarities and differences in the phrasal expression of the different alternations.

With this, the need emerged for a theory allowing simultaneous expression of both the phrasal constituency of a sentence and its more abstract functional syntactic organization. The formal insights leading to the development of Lexical Functional Grammar arose originally from the work of Woods (1970), who explored methods for representing the surface constituent structure of a sentence together with more abstract syntactic information. Building on this work, Kaplan (1975a,b, 1976) realized that placing certain constraints on the representation of abstract syntactic structure and its relation to surface phrasal structure would lead to a simple, formally coherent and linguistically well-motivated grammatical architecture. Based on these formal underpinnings, the relation of the abstract functional syntactic structure of a sentence to its phrase structure could be fully explored. More information about the historical development of the theory is provided by Dalrymple et al. (1995a) and Bresnan et al. (2016).

2. “LEXICAL” AND “FUNCTIONAL”

The name of the theory, “Lexical Functional Grammar”, encodes two important dimensions along which LFG differs from other theories. First, the theory is *lexical* and not transformational: it states relations among different verbal diatheses in the lexicon rather than by means of syntactic transformations. In 1978, when the theory was first proposed, this was a fairly radical idea, but in the intervening years it has come to be much more widely accepted; it is a fundamental assumption of Categorial Grammar (Moortgat 1988; Morrill 1994; Steedman 2001) as well as of Head-Driven Phrase Structure Grammar (Pollard and Sag 1994; Sag et al. 2003; Levine 2017), Construction Grammar (Kay 2002; Boas and Sag 2012), and some works in the transformational tradition (Grimshaw 1990).

Unlike some other theories of syntax, then, the lexicon is not merely a repository for exceptions, a place in which syntactically or semantically exceptional information is recorded. Since LFG is a lexical theory, regularities across classes of lexical items are part of the organization of a richly structured lexicon, and an articulated theory of complex lexical structure is assumed. Work on lexical issues has been an important focus of LFG from the beginning, and this research continues with work to be described in the following pages.

The second dimension that distinguishes Lexical Functional Grammar is that it is *functional* and not configurational: abstract grammatical functions like subject and object are not defined in terms of phrase structure configurations or of semantic or argument structure relations, but are primitives of the theory. LFG shares this view with Relational Grammar (Perlmutter and Postal 1977) and Arc Pair Grammar (Johnson and Postal 1980), as well as with Construction Grammar (Kay 2002; Boas and Sag 2012).

LFG assumes that functional syntactic concepts like subject and object are relevant for the analysis of every language: that the same notions of abstract grammatical functions are at play in the structure of all languages, no matter how dissimilar they seem on the surface. Of course, this does not imply that there are no syntactic differences among languages, or among sentences in different languages that have similar meanings; indeed, the study of abstract syntactic structure in different languages is and has always been a major focus of the theory. Just as the phrase structure of different languages obeys the same general principles (for example, in adherence to *X-bar theory*; see Chapter 3, Section 3.2), in the same way the abstract syntactic structure of languages obeys universal principles of functional organization and draws from a universally available set of possibilities, but may vary from language to language. In this sense, the functional structure of language is said to be “universal.”

In work on the theory of linking between semantic arguments and syntactic functions, similarities and differences among grammatical functions have been closely analyzed, and natural classes of grammatical functions have been proposed. To analyze these similarities, grammatical functions like subject and object are decomposed into more basic features such as ±RESTRICTED, as described in Chapter 9, Section 4.1. On this view, grammatical functions are no longer thought of as atomic. Even given these decompositions, however, the grammatical functions of LFG remain theoretical primitives, in that they are not derived or defined in terms of other linguistic notions such as agenthood or phrasal configuration.

3. STRUCTURE OF THE BOOK

The book consists of three parts. In the first part, Chapter 2 (Functional Structure), Chapter 3 (Constituent Structure), and Chapter 4 (Syntactic Correspondences) examine the two syntactic structures of LFG, the *constituent structure* and the *functional structure*, discussing the nature of the linguistic information they represent, the formal structures used to represent them, and the relation between the two structures. Chapter 5 (Describing Syntactic Structures) and Chapter 6 (Syntactic Relations and Syntactic Constraints) outline the *formal architecture* of LFG and explain how to describe and constrain the constituent structure, the functional structure, and the relation between them. A clear understanding of the concepts presented in Chapter 5 is essential for the discussion in the rest of the book. Chapter 6 is best thought of as a compendium of relatively more advanced formal tools and relations, and may be most profitably used as a reference in understanding the analyses presented in the rest of the book.

The second part of the book explores nonsyntactic levels of linguistic structure and the modular architecture of LFG. Chapter 7 (Beyond C-Structure and F-Structure: Linguistic Representations and Relations) sets the scene for our exploration of other linguistic levels and their relation to constituent structure and functional structure, presenting LFG's *projection architecture* and outlining how different grammatical levels are related to one another. Chapter 8 (Meaning and Semantic Composition) introduces the LFG view of the syntax-semantics interface and semantic representation, according to which the meaning of an utterance is determined via logical deduction from a set of premises associated with the subparts of the utterance. Chapter 9 (Argument Structure and Mapping Theory) discusses the content and representation of *argument structure*, its relation to syntax, and its role in determining the syntactic functions of the arguments of a predicate. Chapter 10 (Information Structure) introduces the level of *information structure*, the structuring of an utterance in context, and explores the relation of information structure to other linguistic levels. Chapter 11 (Prosodic Structure) introduces the level of *prosodic structure*, which analyzes the string in parallel with constituent structure, but with respect to prosodic units rather than phrasal units. Chapter 12 (The Interface to Morphology) discusses the place of morphology in the architecture of LFG, showing how a realizational theory of morphology can be integrated in an LFG setting.

The third part of the book illustrates the concepts of the theory more explicitly by presenting a series of sketches of the syntax and semantics of a range of representative linguistic phenomena. We present the syntactic aspects of the analyses separately from the semantic aspects, so readers who are not interested in formal semantic analysis should still be able to profit from the syntactic discussion in these chapters. In this part, we often leave aside analysis of the information structure, prosody, and morphology of these phenomena, though we sometimes include an analysis at these other aspects as well, in line with the increasing awareness of the importance of adopting a holistic approach and taking account of the interplay of linguistic modules in a full account of the data. Chapter 13 (Modification) discusses the syntax and semantics of modifiers, particularly concentrating on modification of nouns by adjectives. Chapter 14 (Anaphora) presents a theory of the syntax and semantics of anaphoric binding, including both intrasentential and intersentential anaphora. Chapter 15 (Functional and Anaphoric Control) discusses constructions involving control, where the referent of the subject of a subordinate clause is determined by lexical or constructional factors. Chapter 16 (Coordination) presents an analysis of aspects of the syntax and semantics of coordination, and Chapter 17 (Long-Distance Dependencies) discusses long-distance dependencies in topicalization, relative clause formation, and question formation.

The final chapter of the book, Chapter 18 (Related Research Threads and New Directions), discusses LFG-based work in areas not covered elsewhere in the book, as well as new developments in the theory of LFG, including work in historical linguistics and language acquisition, computational and algorithmic research in parsing and generation, LFG-based theories of language acquisition, and Optimality Theory-based work.

The book concludes with three indexes: an index of cited authors, a language index, and a subject index. The language index contains information about the linguistic family to which each cited language belongs, as well as a rough characterization of where the language is spoken.

This book concentrates primarily on the theory of LFG as it has developed since its inception in the late 1970s. The analyses we present are focused on syntactic and nonsyntactic relations and structures within the sentence; we will have far less to say about the structure of larger units of discourse or the relations between sentences.

4. HOW TO USE THE BOOK

Most of the book should be accessible to upper-level undergraduate or graduate students who have some background in syntax. Part I is concerned solely with syntax and its representation by LFG's constituent structure and functional structure. In Part II, we widen the discussion to other modules of grammar, including semantics, argument structure, information structure, prosodic structure, and the morphological component, and their grammatical interfaces. For those whose primary interest is in syntax, the chapters in any of these areas in Part II can be skipped. Part III provides syntactic and semantic analyses of a range of linguistic phenomena; it should be possible to follow the syntactic discussion with only the background provided in Part I, but for the semantic discussions in Part III, familiarity with the material covered in Chapter 8 of Part II will also be necessary. The introduction to Part II provides more information about dependencies among the chapters in Part II and Part III.

Some of the chapters in Part II and Part III will be easier to follow for readers with some background in the areas that are discussed.

- For the semantics chapter in Part II (Chapter 8) and the semantics sections of the chapters in Part III, Gamut (1991a,b) and Partee et al. (1993, Chapter 7) provide useful background.

- Chapter 10 discusses information structure, its representation, and its place in the overall LFG architecture. There is some discussion of information structure in Chapter 17, but it should be possible to follow almost all of the discussion in Chapter 17 even without familiarity with the material presented in Chapter 10. For an overview and introduction to information structure, see Lambrecht (1994) and Erteschik-Shir (2007, Chapters 1–3).

- The content and representation of prosodic structure is discussed in Chapter 11, but does not figure in the analyses presented in Part III. For an introduction to the concepts discussed in Chapter 11, see Selkirk (1984), Nespor and Vogel (2007), and Ladd (2008).

- The analyses presented in Part III also do not include morphological analysis, and so the morphology chapter in Part II (Chapter 12) can be skipped by those who are not concerned with morphology and its interface with the rest of the grammar. Spencer (2004) and Haspelmath and Sims (2011) provide a solid introduction to morphology, and Stewart (2015) provides an overview of contemporary morphological theories. Stump (2001, Chapter 1) is an introduction to issues in morphological theory with a focus on the word-and-paradigm model, providing a theoretical underpinning for the family of realizational theories which that chapter adopts.

5. OTHER LFG OVERVIEWS AND INTRODUCTIONS

Bresnan (2001c), Falk (2001b), and Kroeger (2004) continue to provide invaluable introductions to LFG from different perspectives and for different audiences. Bresnan (2001c) and Falk (2001b) both came out in the same year as the first edition of this book, and each provides an excellent pedagogically-oriented introduction to the theory, including useful exercises. Kroeger (2004) is a lucid introduction to syntactic theory from an LFG perspective, suitable for an introductory syntax course. Bresnan et al. (2016) is a newly revised edition of Bresnan (2001c), updating the treatments presented in the first edition and providing detailed discussion and insights in many new areas.

Besides these book-length introductions, a number of shorter articles provide overviews of the theory from various perspectives. Recent works include Dalrymple (2006), Butt (2008), Lødrup (2011a), Börjars (2011), Nordlinger and Bresnan (2011), Carnie (2012a), Sells (2013), Broadwell (2014), Butt and King (2015), Asudeh and Toivonen (2015), and Dalrymple and Findlay (2018). The on-line proceedings of the LFG conferences (Butt and King 1996–) are also valuable repositories of LFG research. Kuiper and Nokes (2013), Frank (2013), and Müller (2016) provide an overview and comparison of LFG to other grammatical frameworks, and Schwarze and de Alencar (2016) provide a computationally oriented introduction to LFG with a focus on French.

The foundational papers in the Bresnan (1982b) collection provide a snapshot of LFG at the earliest stages of the theory's development. Overviews and summaries at various subsequent stages include Sells (1985), Wescoat and Zaenen (1991), Neidle (1994), Kaplan (1995), Kiss (1995), Neidle (1996), Sadler (1996), Butt et al. (1999), and Austin (2001). The section introductions in Dalrymple et al. (1995b) provide a historical perspective (from the vantage point of the mid-1990s) in a number of areas: Formal Architecture, Nonlocal Dependencies, Word Order, Semantics and Translation, and Mathematical and Computational Issues.

Part I

Syntax

The syntactic component of LFG theory assumes two levels of syntactic structure. Functional structure represents abstract grammatical functions like subject and object as well as abstract features like tense and case. Constituent structure represents the concrete phrasal expression of these relations, governed by language-particular constraints on word order and phrase structure. This duality of syntactic representation is motivated by the different nature of these two structures within and across languages. Languages vary greatly in word order and phrasal structure, and the theory of constituent structure allows for this variation within certain universally-defined parameters. In contrast, all languages share the same functional vocabulary; according to LFG's theory of functional structure, the abstract syntactic structure of every language is organized in terms of subject, object, and other grammatical functions, most of which are familiar from traditional grammatical work. Part I of this book examines the content, structure, and representation of these two levels of linguistic structure, the relations between them, and how they are constrained.

2

FUNCTIONAL STRUCTURE

LFG assumes two different ways of representing syntactic structure, the *constituent structure* or *c-structure* and the *functional structure* or *f-structure*. Within the overall system of linguistic structures, these constitute two subsystems. Functional structure is the abstract functional syntactic organization of the sentence, familiar from traditional grammatical descriptions, representing syntactic predicate-argument structure and functional relations like subject and object. Constituent structure is the overt, more concrete level of linear and hierarchical organization of words into phrases.

Section 1 of this chapter presents motivation for the categories and information appearing in functional structure and outlines some common characteristics of functional structure categories. Section 2 demonstrates that grammatical functions are best treated as primitive concepts, as they are in LFG, rather than defined in terms of morphological or phrase structure concepts. Section 3 shows that *syntactic subcategorization requirements*, the array of syntactic arguments required by a predicate, are best stated in functional terms. The formal representation of functional structure and constraints on f-structure representations are discussed in Section 4. Finally, Section 5 provides an overview of the content and representation of functional structure features.

1. GRAMMATICAL FUNCTIONS AND FUNCTIONAL STRUCTURE

Abstract grammatical relations have been studied for thousands of years. Apollonius Dyscolus, a grammarian in Alexandria in the second century A.D., gave a syntactic description of Ancient Greek that characterized the relations of nouns to verbs and other words in the sentence, providing an early characterization of transitivity and "foreshadow[ing] the distinction of subject and object" (Robins 1967). The role of the subject and object and the relation of syntactic predication were fully developed in the Middle Ages by the modistae, or speculative grammarians (Robins 1967; Covington 1984).

Subsequent work also depends on assuming an underlying abstract regularity operating crosslinguistically. Modern work on grammatical relations and syntactic dependencies was pioneered by Tesnière (1959) and continues in the work of Mel'čuk (1988), Hudson (1990), and others working within the dependency-based tradition. Typological studies are also frequently driven by reference to grammatical relations: for instance, Greenberg (1966b) states his word order universals by reference to subject and object. Thus, LFG aligns itself with approaches in traditional, nontransformational grammatical work, in which these abstract relations were assumed.

1.1. Distinctions Among Grammatical Functions

It is abundantly clear that there are differences in the behavior of phrases depending on their grammatical function. For example, when a question is formed in English, a question phrase appears in initial position. This question phrase may be related to a grammatical function in a subordinate clause, as indicated by the subscript *i* in (1c) and (1d):

(1) a. *Who invited Mary?*
b. *Who did John invite?*
c. *Who$_i$ do you think [___$_i$ invited Mary]?*
d. *Who$_i$ do you think [John invited ___$_i$]?*

However, the subject phrase in such a question may not appear in sentence-initial position if the subordinate clause begins with a word like *that*, though this is possible for the object phrase:[1]

(2) a. **Who$_i$ do you think [that ___$_i$ invited Mary]?*
b. *Who$_i$ do you think [that John invited ___$_i$]?*

In fact, the subject-object distinction is only one aspect of a rich set of distinctions among grammatical functions. Keenan and Comrie (1977, page 66) propose a more fine-grained analysis of abstract grammatical structure, the *Keenan-Comrie*

[1] Ungrammatical examples are standardly marked with an asterisk.

hierarchy or *Accessibility Hierarchy*, stating that "the positions on the Accessibility Hierarchy are to be understood as specifying a set of possible grammatical distinctions that a language may make." They claim that the hierarchy is relevant for various linguistic constructions, including relative clause formation, where it restricts the grammatical function of the argument in the relative clause that is interpreted as coreferent with the modified noun. The border between any two adjacent grammatical functions in the hierarchy can represent a distinction between acceptable and unacceptable relative clauses in a language, and different languages can set the border at different places on the hierarchy:[2]

(3) Keenan-Comrie Hierarchy:

SUBJ > DO > IO > OBL > GEN > OCOMP

In some languages, the hierarchy distinguishes subjects from all other grammatical functions: only the subject of a relative clause can be relativized, or interpreted as coreferent with the noun modified by the relative clause. Other languages allow relativization of subjects and objects in contrast to other grammatical functions. This more fine-grained hierarchical structure allows further functional distinctions to emerge.

Keenan and Comrie speculate that their hierarchy plays a role in the analysis of other grammatical constructions besides relative clause formation, and indeed Comrie (1974) applies the hierarchy in an analysis of grammatical functions in causative constructions. In fact, the Keenan-Comrie hierarchy closely mirrors the "relational hierarchy" of Relational Grammar, as given by Bell (1983), upon which much work in Relational Grammar is based:

(4) Relational Hierarchy of Relational Grammar:

1 (SUBJ) > 2 (OBJ) > 3 (indirect object)

The Obliqueness Hierarchy of Head-Driven Phrase Structure Grammar (Pollard and Sag 1994; Sag et al. 2003) also reflects a hierarchy of grammatical functions like this one. As demonstrated by a large body of work in Relational Grammar, HPSG, LFG, and other theories, the distinctions inherent in these hierarchies are relevant across languages with widely differing constituent structure representations, languages that encode grammatical functions by morphological as well as configurational means. There is a clear and well-defined similarity across languages at this abstract level.

LFG assumes a universally available hierarchy of grammatical functions,[3] with SUBJect at the top of the hierarchy:

[2]The nomenclature that Keenan and Comrie use is slightly different from that used in this book: in their terminology, DO is the direct object, which we call OBJ; IO is the indirect object; OBL is an oblique phrase; GEN is a genitive/possessor of an argument; and OCOMP is an object of comparison.

[3]The grammatical function hierarchy given in (5) lists only grammatical functions that play a role within the clause. We discuss the grammatical function POSS, the function borne by prenominal genitives within the English noun phrase, in Section 1.10.

(5) Functional hierarchy, Lexical Functional Grammar:

SUBJect > OBJect > OBJ_θ> COMP, XCOMP > OBLique$_\theta$ > ADJunct, XADJunct

The labels OBJ_θ and OBL_θ represent families of relations indexed by thematic roles, with the θ subscript representing the thematic role associated with the argument. For instance, $\text{OBJ}_{\text{THEME}}$ is the member of the group of thematically restricted OBJ_θ functions that bears the thematic role THEME, and $\text{OBL}_{\text{SOURCE}}$ and OBL_{GOAL} are members of the OBL_θ group of grammatical functions filling the SOURCE and GOAL thematic roles. These clearly stated relations between thematic roles and grammatical functions reflect a broader generalization about grammatical functions within the LFG framework. As Bresnan et al. (2016, page 9) put it, grammatical functions are the "relators" of phrase structure positions to thematic roles. Structural expressions of a particular grammatical function vary crosslinguistically, but a characteristic mapping to argument structure exists in all cases.

Grammatical functions can be cross-classified in several different ways. The *governable grammatical functions* SUBJ, OBJ, OBJ_θ, COMP, XCOMP, and OBL_θ can be *subcategorized*, or required, by a predicate; these contrast with modifying adjuncts ADJ and XADJ, which are not subcategorizable.

The governable grammatical functions form several natural groups. First, the *terms* or *core arguments* (SUBJ, OBJ, and the family of thematically restricted objects OBJ_θ, discussed in Section 1.6.1 of this chapter) can be distinguished from the family of *nonterm* or *oblique* functions OBL_θ. Crosslinguistically, term functions behave differently from nonterms in constructions involving agreement and control (Chapter 15); we discuss these and other differences between terms and nonterms in Section 1.3 of this chapter.

Second, SUBJ and the primary object function OBJ are the *semantically unrestricted* functions, while OBL_θ and the secondary object function OBJ_θ are restricted to particular thematic roles, as the θ in their name indicates. Arguments with no semantic content, like the subject *it* of a sentence like *It rained*, can fill the semantically unrestricted functions, while this is impossible for the semantically restricted functions. We discuss this distinction in Section 1.4 of this chapter.

Finally, *open* grammatical functions (XCOMP and XADJ), whose subjects are controlled by an argument external to the function, are distinguished from *closed* functions. These are discussed in Section 1.7 of this chapter.

Some linguists have considered inputs and outputs of relation-changing rules like the passive construction to be good tests for grammatical functionhood: for example, an argument is classified as an object in an active sentence if it appears as a subject in the corresponding passive sentence, under the assumption that the passive rule turns an object into a passive subject. However, as we discuss in Chapter 9, grammatical function alternations like the passive construction are best viewed not in terms of transformational rules, or even in terms of lexical rules manipulating grammatical function assignments, but in terms of a characterization of possible mappings between thematic roles and grammatical functions. Therefore, appeal to these processes as viable diagnostics of grammatical functions requires a thorough understanding of the theory of argument linking, and these diagnostics must be used with care.

In the rest of this chapter, we present the inventory of grammatical functions assumed in LFG theory and discuss a variety of grammatical phenomena that make reference to these functions. Some of these phenomena are sensitive to a grammatical hierarchy, while others can refer either to specific grammatical functions or to a larger class of functions. Thus, the same test (for example, relativizability) might distinguish subjects from all other grammatical functions in one language, but might group subjects and objects in contrast to other grammatical functions in another language. A number of tests are also specific to particular languages or to particular types of languages: for example, switch-reference constructions, constructions in which a verb is inflected according to whether its subject is coreferential with the subject of another verb, do not constitute a test for subjecthood in a language in which switch-reference plays no grammatical role. In a theory like LFG, grammatical functions are theoretical primitives, not defined in phrasal or semantic terms; therefore, we do not define grammatical functions in terms of a particular, invariant set of syntactic behaviors. Instead, grammatical phenomena can be seen to cluster and distribute according to the grammatical organization provided by these functions.

1.2. Governable Grammatical Functions and Modifiers

A major division in grammatical functions is the distinction between arguments of a predicate and modifiers. The arguments are the *governable grammatical functions* of LFG; they are subcategorized for, or *governed*, by the predicate. Modifiers modify the phrase with which they appear, but they are not governed by the predicate.

(6) Governable grammatical functions:

$$\underbrace{\text{SUBJ OBJ OBJ}_\theta \text{ XCOMP COMP OBL}_\theta}_{\text{GOVERNABLE GRAMMATICAL FUNCTIONS}} \qquad \underbrace{\text{ADJ XADJ}}_{\text{MODIFIERS}}$$

A number of identifying criteria for governable grammatical functions have been proposed. Dowty (1982) proposes two tests to distinguish between governable grammatical functions and modifiers: what he calls the *entailment test*, namely that using a predicate entails the existence of all of its arguments, but not its modifiers; and what he calls the *subcategorization test*, namely that it is possible to omit modifiers but not arguments when a predicate is used. These tests do capture some intuitively correct properties of the distinction between governable grammatical functions and modifiers; however, neither test is completely successful in distinguishing between them.

Dowty's first test, the entailment test, fails for some phrases that seem uncontroversially to be modifiers. In particular, since the use of many predicates entails that some event occurred at some place at some time, the test implies that temporal modifiers are arguments of those predicates. For instance, the use of the verb *yawned* in a sentence like *David yawned* entails that there was some past time at which David yawned; however, few linguists would conclude on this basis that *previously* is an argument of *yawned* in a sentence like *David yawned previously*. Additionally, as pointed out by Anette Frank (p.c.), the entailment test incorrectly predicts that the object argument of an intensional verb such as *deny* or *seek* is not a governable grammatical function, since a sentence like *David is seeking a solution to the problem* does not imply that a solution exists. Further, syntactically required but semantically empty phrases that are governed by a predicate are not classified as syntactic arguments by this test; the existence of some entity denoted by the subject of *rained* is not entailed by the sentence *It rained*.

Dowty's second test is also problematic. It clearly fails in "pro-drop" languages — languages where some or all arguments of a predicate can be omitted — but even in English the test does not work well. The test implies that because a sentence like *David ate* is possible, the object *lunch* in *David ate lunch* is not an argument but a modifier.

Even though Dowty's tests do not succeed in correctly differentiating arguments and modifiers, certain valid implications can be drawn from his claims. If a phrase is an argument, it is either obligatorily present or it is entailed by the predicate. If a phrase is a modifier, it can be omitted. Stronger conclusions do not seem to be warranted, however.

A number of other tests have been shown to illuminate the distinction between arguments and modifiers:[4]

Multiple occurrence: Modifiers can be multiply specified, but arguments cannot, as noted by Kaplan and Bresnan (1982):

(7) a. *The girl handed the baby a toy <u>on Tuesday</u> <u>in the morning</u>.*
b. **David saw <u>Tony</u> <u>George</u> <u>Sally</u>.*

VP anaphora: It is possible to add modifiers to a clause containing *do so*, but not arguments (Lakoff and Ross 1976):

(8) a. *John bought a book <u>last Friday</u> and I did so <u>today</u>.*
b. **John bought <u>a book</u> and I did so <u>a magazine</u>.*

Alternation: Only arguments can alternate with subjects and objects; see Needham and Toivonen (2011):

(9) a. *The patient benefited <u>from the medicine</u>.*
b. *<u>The medicine</u> benefited the patient.*

Anaphoric binding patterns: In some languages, binding patterns are sensitive to the syntactic argument structure of predicates and therefore to the argument/modifier distinction. For example, as we discuss in Chapter 14, Section 2.1,

[4] These tests do not give clear-cut results in all cases. For discussion of contentious cases, see Chapter 9, Section 10.5.

the Norwegian reflexive pronoun *seg selv* requires as its antecedent a coargument of the same predicate. Since a modifier is not an argument of the main predicate, the reflexive *seg selv* may not appear in a modifier phrase if its antecedent is an argument of the main verb (Hellan 1988; Dalrymple 1993). Coreference between the anaphor and its intended antecedent is indicated by coindexation, here using the subscript *i*:

(10) *Jon forakter seg selv.*
Jon despises self
'Jon$_i$ despises himself$_i$.'

(11) *Jon fortalte meg om seg selv.*
Jon told me about self
'Jon$_i$ told me about himself$_i$.'

(12) **Hun kastet meg fra seg selv.*
She threw me from self
'She$_i$ threw me away from herself$_i$.'

In (10) and (11) the reflexive's antecedent is the subject *Jon*, which is an argument of the same verbal predicate. By contrast, when the reflexive appears as part of a modifier phrase, as in (12), the sentence is ungrammatical.

Order dependence: The contribution of modifiers to semantic content can depend on their relative order, as noted by Pollard and Sag (1987, 5.6). The meaning of a sentence may change if its modifiers are reordered: example (13a) is true if Kim jogged reluctantly, and this happened twice a day, while example (13b) is true if Kim jogged twice a day, but did so reluctantly (but perhaps would have been happy to jog once a day, or three times a day).

(13) a. *Kim jogged <u>reluctantly</u> <u>twice a day</u>.*
b. *Kim jogged <u>twice a day</u> <u>reluctantly</u>.*

In contrast, reordering arguments may affect the meaning of the sentence, focusing attention on one or another argument, but does not alter the conditions under which the sentence is true.

Extraction patterns: A long-distance dependency cannot relate a question phrase that appears in sentence-initial position to a position inside some modifiers, as noted by Pollard and Sag (1987, section 5.6) (see also Huang 1982; Rizzi 1990):

(14) a. **Which famous professor did Kim climb K2 without oxygen in order to impress ___?*
b. *Which famous professor did Kim attempt to impress ___ by climbing K2 without oxygen?*

This generalization is not as robust as those discussed above, since as Pollard and Sag point out, it is possible to extract a phrase from some modifiers:

(15) *Which room does Julius teach his class in ___?*

1.3. Terms and Nonterms

The governable grammatical functions can be divided into *terms* or direct functions, and *nonterms* or obliques. The subject and object functions are grouped together as terms:[5]

(16) Terms and nonterms:

$$\underbrace{\text{SUBJ OBJ OBJ}_\theta}_{\text{TERMS}} \quad \underbrace{\text{OBL}_\theta \text{ XCOMP COMP}}_{\text{NONTERMS}}$$

A number of tests for termhood in different languages have been proposed.

AGREEMENT: In some languages, termhood is correlated with verb agreement; in fact, this observation is encoded in Relational Grammar as the Agreement Law (Frantz 1981): "Only nominals bearing term relations (in some stratum) may trigger verb agreement." Alsina (1993), citing Rosen (1990) and Rhodes (1990), notes that all terms, and only terms, trigger verb agreement in Ojibwa and Southern Tiwa.

CONTROL: Kroeger (1993) shows that in Tagalog, only a term can be the controllee in the participial complement construction, and only a term can be a controller in the participial adjunct construction. The sentences in (17) are examples of the participial complement construction. The controllee can be a term (17a,b), but never a nonterm (17c).

(17) a. *In-abut-an ko siya=ng [nagbabasa* ___$_{\text{TERM}}$
PFV-find-DV 1SG.GEN 3SG.NOM=COMP AV.IPFV.read
ng=komiks sa=eskwela].
GEN=comics DAT=school
'I caught him reading a comic book in school.'

b. *In-iwan-an ko siya=ng [sinusulat* ___$_{\text{TERM}}$
PFV-leave-DV 1SG.GEN 3SG.NOM=COMP IPFV.write.OV
ang=liham].
NOM=letter
'I left him writing the letter.'

c. **In-abut-an ko si=Luz na [ibinigay ni=Juan*
PFV-find-DV 1SG.GEN NOM=Luz LINK IV.IPFV.give GEN=Juan
ang=pera ___$_{\text{OBL}_{\text{GOAL}}}$ *].*
NOM=money

[5] Relational grammar (Perlmutter and Postal 1983) also recognizes this basic division of grammatical functions into "term relations" and "oblique relations." Terms are also sometimes referred to as "core functions" (Andrews 2007a; Bresnan et al. 2016).

'I caught Luz being given money by Juan.'

Alsina (1993) provides an extensive discussion of termhood in a number of typologically very different languages, and Andrews (2007a) further discusses the term/nonterm distinction.

Often, discussion of terms focuses exclusively on the status of nominal arguments of a predicate, and does not bear on the status of verbal or sentential arguments. The infinitive phrase *to be yawning* in example (18) bears the open grammatical function XCOMP:

(18) *Chris seems to be yawning.*

The clausal complement *that Chris was yawning* bears the grammatical function COMP in (19):

(19) *David thought that Chris was yawning.*

The XCOMP function differs from the COMP function in not containing an overt SUBJ internal to its phrase; XCOMP is an open function, whose SUBJ is determined by means of lexical specifications on the predicate that governs it, as discussed in Section 1.7 of this chapter. What is the termhood status of the XCOMP and COMP arguments?

Zaenen and Engdahl (1994) classify XCOMP as a kind of oblique in their analysis of the linking of sentential and predicative complements, though without providing explicit evidence in support of this classification. Oblique arguments are nonterms, and so if Zaenen and Engdahl are correct, XCOMP would be classified as a nonterm.

Word order requirements on infinitival and finite complements in English provide some support for this position. Sag (1987) claims that in English, term phrases always precede obliques:

(20) a. *David gave a book to Chris.*

b. **David gave to Chris a book.*

Infinitival and clausal complements bearing the grammatical functions XCOMP and COMP obey different word order restrictions from term noun phrases. The following data indicate that XCOMPS are obliques:

(21) a. *Kim appeared to Sandy to be unhappy.*

b. *Kim appeared to be unhappy to Sandy.*

Since the XCOMP *to be unhappy* is not required to precede the oblique phrase *to Sandy* but can appear either before or after it, Sag's diagnostic indicates that the XCOMP must also be an oblique. Similar data indicate that COMP is also an oblique phrase:

(22) a. *David complained that it was going to rain to Chris.*

b. *David complained to Chris that it was going to rain.*

We will return to a discussion of COMP and XCOMP in Section 1.7 of this chapter.

1.4. Semantically Restricted and Unrestricted Functions

The governable grammatical functions can be divided into *semantically restricted* and *semantically unrestricted* functions (Bresnan 1982a):

(23) Semantically unrestricted and restricted functions:

$$\underbrace{\text{SUBJ OBJ}}_{\text{SEMANTICALLY UNRESTRICTED}} \quad \underbrace{\text{OBJ}_\theta \ \text{OBL}_\theta}_{\text{SEMANTICALLY RESTRICTED}}$$

Semantically unrestricted functions like SUBJ and OBJ can be associated with any thematic role, as Fillmore (1968) shows:

(24) a. *He hit the ball.*

b. *He received a gift.*

c. *He received a blow.*

d. *He loves her.*

e. *He has black hair.*

The examples in (24) show that the SUBJ of different verbs can be associated with different thematic roles: AGENT in a sentence like *He hit the ball*, GOAL in a sentence like *He received a gift*, and so on. Similar examples can be constructed for OBJ.

In contrast, members of the semantically restricted family of functions OBJ_θ and OBL_θ are associated with a particular thematic role. For example, the $\text{OBJ}_{\text{THEME}}$ function is associated only with the thematic role of THEME, and the OBL_{GOAL} is associated with GOAL. Languages may differ in the inventory of semantically restricted functions they allow. For example, English allows only $\text{OBJ}_{\text{THEME}}$:

(25) a. *I gave her $\underbrace{\textit{a book}}_{\text{THEME}}$.*

b. *I made her $\underbrace{\textit{a cake}}_{\text{THEME}}$.*

c. *I asked him $\underbrace{\textit{a question}}_{\text{THEME}}$.*

Other thematic roles cannot be associated with the second object position, underlined in these examples:

(26) a. **I made a cake $\underbrace{\textit{the teacher}}_{\text{GOAL}}$.*

b. **I cut the cake $\underline{\text{a knife}}$.*
INSTRUMENT

Section 1.6 of this chapter provides a more complete discussion of object functions, including the double object construction and verb alternations; see also Levin (1993).

The division between semantically restricted and semantically unrestricted arguments predicts what in Relational Grammar is called the Nuclear Dummy Law (Frantz 1981; Perlmutter and Postal 1983): only semantically unrestricted functions can be filled with semantically empty arguments like the subject *it* of *It rained*. This is because the semantically restricted functions are associated with a particular thematic role; since a semantically empty argument is incompatible with these semantic requirements, it cannot fill a semantically restricted role.

The functions XCOMP and COMP have rarely figured in discussions of semantically restricted and unrestricted arguments, and the question of how they should be classified remains under discussion. There does seem to be some evidence for classifying COMP as semantically *unrestricted*, since different semantic entailments can attach to different uses of XCOMP and COMP, as shown in a pioneering paper by Kiparsky and Kiparsky (1970). If these different entailment patterns are taken to indicate that XCOMP and COMP can be associated with different thematic roles, then XCOMP and COMP should be classified as semantically unrestricted.

Kiparsky and Kiparsky (1970) note that clausal complements bearing the COMP function may be *factive* or *nonfactive*: for factive complements, "the embedded clause expresses a true proposition, and makes some assertion about that proposition," whereas such a presupposition is not associated with nonfactive complements. Kiparsky and Kiparsky also distinguish *emotive* from *nonemotive* sentential arguments; emotive complements are those to which a speaker expresses a "'subjective, emotional, or evaluative reaction":

(27) a. Factive emotive: *I am pleased that David came.*

b. Factive nonemotive: *I forgot that David came.*

c. Nonfactive emotive: *I prefer that David come.*

d. Nonfactive nonemotive: *I suppose that David came.*

It is not clear, however, whether the semantic differences explored by Kiparsky and Kiparsky should be taken to indicate that these arguments, which all bear the grammatical function COMP in English, bear different thematic roles.

Zaenen and Engdahl (1994) take a different position, arguing that XCOMP — and therefore, by extension, COMP — is restricted in that only propositional arguments can fill these two functions, a constraint which they claim is directly comparable to being semantically restricted (see also Falk 2005). In their analysis of complement clauses, Dalrymple and Lødrup (2000) also assume that COMP is semantically restricted, a feature which distinguishes COMP from OBJ and which is central to their proposal; see Section 1.7 of this chapter.

Falk (2001b, pages 137–141) presents an alternative view, one which does not involve the semantically restricted/unrestricted distinction. He assumes that COMP and XCOMP, as propositional arguments, are distinguished from all other grammatical functions by having a positive value for a special feature [c]. Falk (2001b, page 133) characterizes this as a "more cautious position" than that of Zaenen and Engdahl (1994), with which it shares some foundational assumptions. Berman's (2007) analysis of German represents yet another approach: she claims that COMP is an underspecified complement function, which may be either restricted or unrestricted depending on the context. This underspecified analysis offers a different view of COMP and the possible reasons why it has proved so difficult to categorize with respect to the semantically restricted/unrestricted distinction.

We have explored several natural classes of grammatical functions: governable grammatical functions and modifiers, terms and nonterms, semantically restricted and unrestricted functions. We now turn to an examination of particular grammatical functions, beginning with the subject function.

1.5. SUBJ

The subject is the term argument that ranks the highest on the Keenan-Comrie relativization hierarchy. As discussed in Section 1.1 of this chapter, Keenan and Comrie's hierarchy is applicable to a number of processes including relativization: if only one type of argument can participate in certain processes for which a grammatical function hierarchy is relevant, that argument is often the subject.

There is no lack of tests referring specifically to the subject function.

AGREEMENT: The subject is often the argument that controls verb agreement in languages in which verbs bear agreement morphology; indeed, Moravcsik (1978) proposes the following language universal:

> There is no language which includes sentences where the verb agrees with a constituent distinct from the intransitive subject and which would not also include sentences where the verb agrees with the intransitive subject. (Moravcsik 1978, page 364)

English is a language that exhibits subject-verb agreement; the fullest paradigm is found in the verb *to be*:

(28) *I am* / *You are* / *He is*

HONORIFICATION: Matsumoto (1996) calls this the most reliable subject test in Japanese. Certain honorific forms of verbs are used to honor the referent of the subject:

(29) *sensei wa hon o o-yomi ni narimashi-ta*
teacher TOPIC book ACC HONORIFIC-read COPULA become.POLITE-PST
'The teacher read a book.'

The verb form *o-V ni narimasu* is used to honor the subject *sensei* 'teacher'. It cannot be used to honor a nonsubject, even if the argument is a "logical subject"/agent. Like example (29), example (30) is grammatical because the honorific verb form is used to honor the subject *sensei* 'teacher':

(30) *sensei wa Jon ni o-tasuke-rare ni narimashi-ta*
teacher TOPIC John by HONORIFIC-help-PASS COPULA become.POLITE-PST
'The teacher was saved by John.'

A proper name is used only when the referent is not superior to the speaker in age or social rank: example (31) is unacceptable because *Jon* is not an appropriate target of honorification, and *sensei* is not the subject:

(31) **Jon wa sensei ni o-tasuke-rare ni narimashi-ta*
John TOPIC teacher by HONORIFIC-help-PASS COPULA become.POLITE-PST
'John was saved by the teacher.'

SUBJECT NONCOREFERENCE: Mohanan (1994) shows that the antecedent of a pronoun in Hindi cannot be a subject in the same clause, although a nonsubject antecedent is possible. In example (32), the possessive pronoun *uskii* cannot corefer with *Vijay* (as indicated by the asterisk on the subscript *i*), though coreference with *Ravii* (*j*) or another individual (*k*) is possible:

(32) *Vijay ne Ravii ko uskii saikil par biṭhaayaa*
Vijay ERG Ravi ACC his bicycle LOC sit.CAUS.PRF
'Vijay$_i$ seated Ravi$_j$ on his$_{*i,j,k}$ bike.'

LAUNCHING FLOATED QUANTIFIERS: Kroeger (1993, page 22) shows that the subject launches *floating quantifiers*, quantifiers that appear outside the phrase they quantify over, in Tagalog.[6]

(33) *sinusulat lahat ng-mga-bata ang-mga-liham*
IPRF.write.OV all GEN-PL-child NOM-PL-letter
'All the letters are written by the/some children.'
(Does not mean: 'All the children are writing letters.')

Bell (1983, pages 154 ff.) shows that the same is true in Cebuano.

This is only a sampling of the various tests for subjecthood. Many other tests could, of course, be cited (see, for example, Andrews 2007a; Falk 2006; Li 1976; Zaenen 1982; Zaenen et al. 1985).

The question of whether every clause has a SUBJ is controversial. The Subject Condition[7] was discussed by Bresnan and Kanerva (1989), who attribute it originally to Baker (1983) (see also Levin 1987; Butt et al. 1999):

[6]Kroeger attributes example (33) to Schachter (1976).

[7]The Subject Condition is called the *Final 1 Law* in Relational Grammar (Frantz 1981; Perlmutter and Postal 1983) and the *Extended Projection Principle* in Chomskyan generative grammar (Chomsky 1981).

(34) Subject Condition:

Every verbal predicate must have a SUBJ.

Though the Subject Condition seems to hold in English, and perhaps in many other languages as well, there are languages in which the requirement does not so clearly hold. For example, German impersonal passives, as in (35), are traditionally analyzed as subjectless clauses:

(35) ... *weil* *getanzt* *wird*
because danced become.PRS.3SG
'because there is dancing'

However, Berman (1999, 2003) claims that clauses like (35) contain an unpronounced expletive subject and thus that the Subject Condition is not violated. She argues that in a German impersonal passive construction the verbal agreement morphology (specifically the 3SG form) introduces a subject that has only person and number agreement features: that is, an expletive subject without semantic content. In this way, every finite clause in German satisfies the Subject Condition.

Kibort (2006) discusses Polish constructions which, similar to the German construction in (35), appear to be subjectless. These clauses contain one of a small number of inherently impersonal predicates, such as *słychać* 'hear', as in (36a), or an intransitive predicate which has been passivized, as in (36b), which is similar to the German example in (35). In (36a), the lack of a syntactic subject is reflected in the form of the verb used: the verb *słychać* 'hear' has the same form as the infinitive. Since this is a non-finite verb form, there is no agreement morphology to introduce subject features, in contrast to the German construction analyzed by Berman. (36b) contains the passivized form of an intransitive predicate, *było sypane* 'has been spreading', which bears default impersonal agreement (3SG.N). The agent can optionally appear as an oblique argument.

(36) a. *Słychać* *ją* / *jakieś* *mruczenie.*
hear her.ACC some.N.ACC murmuring.(N).ACC
'One can hear her/some murmuring.'

b. *Czy* *na* *tej* *ulicy* *już* *było* *sypane* *(przez*
Q on this street already was.3SG.N throw/spread.PTCP.SG.N by
kogokolwiek)?
anyone
'Has there already been spreading [of grit] on this street (by anyone)?'

On the basis of such data, Kibort (2006) argues that truly subjectless constructions exist in Polish. It may be, then, that the Subject Condition is a language-particular requirement imposed by some but not all languages, rather than a universal requirement.

An alternative, more fine-grained view of subject properties and the notion of subjecthood is explored in detail by Falk (2006). The core of Falk's proposal is that the grammatical function subject represents the conflation of two distinct functions: the element that expresses the most prominent argument of the verb ($\widehat{\text{GF}}$) and the element that connects its clause to other clauses in a sentence (PIVOT). Prominence in the case of $\widehat{\text{GF}}$ is defined in terms of the mapping between the thematic hierarchy (comprising thematic roles such as agent, theme, location) and the relational hierarchy (comprising grammatical functions). Falk (2006, page 39) thus defines $\widehat{\text{GF}}$ as being "the element with the function of expressing as a core argument the hierarchically most prominent argument", and argues that a subset of 'subject properties' — those relating to argument hierarchies, such as the antecedent of a reflexive or the addressee of an imperative — are in fact $\widehat{\text{GF}}$ properties, whereas those 'subject properties' relating to elements shared between clauses are PIVOT properties.

In languages like English, with nominative-accusative alignment, $\widehat{\text{GF}}$ and PIVOT always coincide, and the argument which we have identified as SUBJ exhibits both $\widehat{\text{GF}}$ and PIVOT properties. However, Falk claims that other alignments are possible, and that in what he calls 'mixed-subject' languages, PIVOT is not necessarily identified with $\widehat{\text{GF}}$. Mixed subject languages include those which have been described as syntactically ergative: in a syntactically ergative language, PIVOT is the object if there is one, and otherwise PIVOT is $\widehat{\text{GF}}$. For example, in the syntactically ergative language Greenlandic, $\widehat{\text{GF}}$ plays an important role in anaphoric binding: the antecedent of a reflexive is $\widehat{\text{GF}}$, not PIVOT. This is shown in (37), where the antecedent of the reflexive pronoun is the single argument of the intransitive verb 'go' or the more agentive argument of the transitive verb 'trust'.[8]

(37) a. *Aani illu-mi-nut ingerlavoq.*
Anne house-REFL.POSS-DAT go
'Anne$_i$ is going to her$_i$ house.'

b. *Ataata-ni Juuna-p tatig(i-v)aa.*
father-REFL.POSS Juuna-ERG trust
'Juuna$_i$ trusts his$_i$ father.'

However, PIVOT and not $\widehat{\text{GF}}$ is the target of relativization in relative clause formation: the relativized argument is the single argument of the intransitive predicate 'angry' or the object of 'kill', but not the $\widehat{\text{GF}}$ of 'take'.

(38) a. *miiraq [kamattuq]*
child angry.SG
'the child [who ___ is angry]'

b. *nanuq [Piita-p tuqua]*
polar.bear Peter-ERG kill.3SG
'a polar bear [that Peter killed ___]'

c. **angut [aallaat tigusimasaa]*
man gun take.3SG
'the man [who ___ took the gun]'

[8] Falk attributes the examples in (37) and (38) to Manning (1996b). We present them in simplified form, leaving out morphological detail.

So-called ‘Philippine-type’ languages are also mixed languages: in a Philippine-type language such as Tagalog, lexical marking on the verb determines which of the verb’s arguments is identified with PIVOT. In such languages, $\widehat{\text{GF}}$ and PIVOT properties diverge in the same way as in syntactically ergative languages.

Falk (2006) proposes that $\widehat{\text{GF}}$ plays a role in all languages, in the sense that all languages have clauses including $\widehat{\text{GF}}$ as an argument. However, he holds that the requirement for all clauses to include $\widehat{\text{GF}}$ as an argument holds only for some languages, similar to Kibort’s (2006) claims in relation to the Subject Condition. In particular, Falk (2006, page 170) proposes that certain intransitive Acehnese verbs (those with agentive subjects, such as ‘go’) require a $\widehat{\text{GF}}$, while certain others (those with nonagentive subjects, such as ‘fall’) require an object, not $\widehat{\text{GF}}$. PIVOT has a different status: Falk tentatively proposes that some languages, including Choctaw/Chickasaw and Warlpiri, lack a PIVOT altogether. Such languages would be expected to lack pivot-sensitive constructions such as long-distance dependencies and functional control constructions.

In order to maintain consistency with the vast majority of previous work in the LFG framework and because the distinction between $\widehat{\text{GF}}$ and PIVOT is not crucial to the analyses we present, we will continue to use SUBJ. However, this does not mean that we reject the important distinctions involving different aspects of the SUBJ role that Falk explores.

1.6. The Object Functions

Grammatical phenomena in which a functional hierarchy is operative may sometimes group subject and object arguments together in distinction to other arguments, and in fact a number of grammatical processes refer to subject and object functions in distinction to other grammatical functions. Other phenomena are describable specifically in terms of the object function; for the purposes of our current discussion, these object tests are more interesting. Some of these are:

AGREEMENT: As noted in Section 1.3 of this chapter, terms are often registered by agreement morphemes on the verb. Often, the object is uniquely identified by agreement. For example, Georgopoulos (1985) describes OBJ agreement in Palauan:

(39) *ak-uldenges-terir a resensei er ngak*
1SG.PRF-honor-3PL teachers PREP me
‘I respected my teachers.’

In (39), the morpheme *-terir* encodes third person plural agreement with the OBJ *a resensei* ‘teachers’.

CASEMARKING: In some limited circumstances, objects can be distinguished by casemarking, though this test must be used with care: in general, there is no one-to-one relation between the morphological case that an argument bears and its grammatical function, as we will see in Section 2.1 of this chapter. Mohanan

(1982) discusses casemarking in Malayalam, showing that ACCusatively marked noun phrases are unambiguously objects (see also Mohanan 1994, pages 89–90):

(40) *kuṭṭi aanaye ṉuḷḷi*
child elephant.ACC pinched
'The child pinched the elephant.'

However, Mohanan goes on to show that many phrases in Malayalam that are OBJ are not marked with ACC case. That is, every phrase in Malayalam that is ACC is an OBJ, but not all OBJs are ACC.

RELATIVIZATION: Givón (1997, section 4.4.3) notes that only subjects and objects can be relativized in Kinyarwanda, and only objects can be relativized with a gap; relativization of subjects requires the use of a resumptive pronoun.

Further discussion of object tests is provided by Baker (1983) for Italian, Dahlstrom (1986b) for Cree, and Hudson (1992) for English. Andrews (2007a) also provides a detailed discussion of object tests in various languages.

1.6.1. MULTIPLE OBJECTS

In many languages it is possible to have more than one phrase bearing an object function in a sentence. English is one such language:

(41) *He gave <u>her</u> <u>a book</u>.*

Zaenen et al. (1985) discuss Icelandic, another language with multiple object functions, and note the existence of asymmetries between the two kinds of objects. For instance, the primary object can be the antecedent of a reflexive contained in the secondary object:

(42) *Ég gaf ambáttina [konungi sínum].*
I gave slave.DEF.ACC king.DAT self's
'I gave the slave_i to self's_i king.'
OBJ OBJ2

However, the secondary object cannot antecede a reflexive contained in the primary object:

(43) **Sjórinn svipti manninum [gömlu konuna sína].*
sea.DEF deprived man.DEF.DAT old wife.DEF.ACC self's
'The sea deprived self's_i old wife of the man_i.'
OBJ OBJ2

Dryer (1986) also presents an extensive discussion of the behavior of objects in languages with multiple OBJ functions and their groupings with respect to thematic roles.

Earlier work in LFG concentrated on languages like English and Icelandic, which each have two object functions. In such languages, the primary object was called the OBJ, and the secondary object was called the OBJ2, as in examples (42)–(43). Further research has expanded our knowledge of the properties of objects, and in later work it became evident that this simple classification is neither sufficient nor explanatory.

In fact, languages allow a single *thematically unrestricted* object, the primary OBJ. In addition, languages may allow one or more secondary, *thematically restricted* objects. That is, the argument that was originally identified as OBJ2 in English is only one member of a family of semantically restricted functions, referred to collectively as OBJ_θ (Bresnan and Kanerva 1989). This classification more clearly reflects the status of secondary objects as restricted to particular thematic roles, and also encompasses analyses of languages whose functional inventory includes more than two object functions.

In English, as discussed in Section 1.4 of this chapter, the thematically restricted object must be a theme; other thematic roles, such as goal or beneficiary, are not allowed:

(44) a. *I made her <u>a cake</u>.*

b. **I made a cake <u>her</u>.*

In contrast, as Bresnan and Moshi (1990) show, languages like Kichaga allow multiple thematically restricted objects with roles other than THEME:[9]

(45) *n-ã́-l*ꜜ*é-kú-shí-kí-kó̩r-í-à*
FOCUS-1SUBJ-PST-17OBJ-8OBJ-7OBJ-cook-APPL-FV
'She/he cooked it with them there.'

This example contains three object markers, representing a locative object (17OBJ), an instrumental object (8OBJ), and a patient object (7OBJ). According to Bresnan and Moshi's analysis, in this example the instrumental OBJ is the unrestricted OBJ; the locative and patient arguments bear thematically restricted OBJ functions OBJ_{LOC} and $\text{OBJ}_{\text{PATIENT}}$. Bresnan and Moshi provide much more discussion of OBJ_θ in Kichaga and other Bantu languages.

While the division of the object functions into thematically unrestricted OBJ and a family of thematically restricted object functions (OBJ_θ) represents the mainstream approach in LFG, the notion of object and its possible subtypes remains relatively understudied, as Börjars and Vincent (2008) point out. In a paper which considers object as a pretheoretical construct as well as the concept OBJ within LFG, Börjars and Vincent (2008) argue that the object role is not associated with specific semantic content but should rather be viewed as a "semantically inert" grammatical function.

[9] Numbers in the glosses indicate the noun class of the arguments.

1.6.2. 'Direct' and 'Indirect' Object

In traditional grammatical descriptions, the grammatical function borne by *her* in the English example in (46) has sometimes been called the "indirect object," and *a book* has been called the "direct object":

(46) *He gave her a book.*

The phrase *a book* is also traditionally assumed to be a direct object in examples like (47):

(47) *He gave a book to her.*

The classification of *a book* as a direct object in both (46) and (47) may have a semantic rather than a syntactic basis: there may be a tendency to assume that *a book* must bear the same grammatical function in each instance because its thematic role does not change. The LFG view differs: in example (46), the phrase *her* bears the OBJ function, while in example (47), the phrase *a book* is the OBJ.

Within the transformational tradition, evidence for the LFG classification of English objects came from certain formulations of the rule of passivization, which applies uniformly to "transform" an object into a subject:

(48) a. Active: *He gave <u>her</u> a book.*
Passive: *<u>She</u> was given a book.*

b. Active: *He gave <u>a book</u> to her.*
Passive: *<u>A book</u> was given to her.*

If the "passive transformation" is stated in terms of the indirect object/object distinction, or its equivalent in phrase structure terms, the generalization is complicated to state: the direct object becomes the passive subject only if there is no indirect object present; otherwise, the indirect object becomes the subject. On the other hand, the transformation is easy to state if the first noun phrase following the verb is classified as the object and the second bears some other function. In LFG, however, the theory of grammatical function alternations is formulated in terms of a characterization of possible mappings between thematic roles and grammatical functions, as described in Chapter 9, and is not transformational in nature. Thus, we must look to other grammatical phenomena for evidence bearing on the classification of object functions.

Dryer (1986) presents several arguments that in English, an opposition between primary/unrestricted objects (OBJ) and secondary/restricted objects (OBJ_θ), as proposed in LFG, allows a more satisfactory explanation of the facts than the direct/indirect object distinction. Dryer primarily discusses evidence from prepositional casemarking and word order. For example, given a distinction between primary and secondary objects, we can succinctly describe word order within the

English VP: the primary object immediately follows the verb, with the secondary object following it.[10]

In other languages, the situation is even clearer. Alsina (1993) examines the object functions in Chicheŵa and their role in the *applicative* construction. In this construction, an affix is added to the verb to signal a requirement for an additional syntactic argument besides the arguments ordinarily required by the verb; we focus here on the *benefactive applicative* construction, in which the applicative affix signals that an OBJ argument bearing a beneficiary thematic role is required. Alsina (1993) shows that the syntactic OBJ properties of the patient argument in the nonapplied form are displayed by the beneficiary argument in the applied form. The primary/nonrestricted OBJ is the argument that immediately follows the verb; this argument is the patient in the nonapplied form, and the beneficiary in the applied form of the verb:

(49) a. *nkhandwe zi-ku-mény-á njōvu*
10.foxes 10SUBJ-PRS-hit-FV 9.elephant
'The foxes are hitting the elephant.'

b. *nkhandwe zi-ku-mény-ér-a aná njōvu*
10.foxes 10SUBJ-PRS-hit-APPL-FV 2.children 9.elephant
'The foxes are hitting the elephant for the children.'

The patient argument alternates with the OBJ marker in the nonapplied form, and the beneficiary argument alternates with the OBJ marker in the applied form:

(50) a. *nkhandwe zi-ku-í-mḗny-a*
10.foxes 10SUBJ-PRS-9OBJ-hit-FV
'The foxes are hitting it [the elephant].'

b. *nkhandwe zi-ku-wá-mény-er-á njōvu*
10.foxes 10SUBJ-PRS-2OBJ-hit-APPL-FV 9.elephant
'The foxes are hitting the elephant for them [the children].'

This and other evidence is best explained by assuming that the patient argument in (49a) and (50a) and the beneficiary argument in (49b) and (50b) each bear the nonrestricted/primary OBJ function, while the patient argument in (49b) and (50b) bears the restricted/secondary OBJ$_\theta$ function and behaves differently. In other words, the syntactic behavior of the arguments in examples (49) and (50) is best explained by reference to a distinction between OBJ and OBJ$_\theta$, not between direct and indirect objects.

Although OBJ$_\theta$ can be regarded as a secondary object function, this does not mean that OBJ$_\theta$ appears only when an OBJ argument is also required. Drawing on patterns involving passivization, causativization and raising, Çetinoğlu and Butt (2008) present data which support an analysis of certain Turkish transitive verbs as subcategorizing for a SUBJ and an OBJ$_\theta$. Similarly, Dahlstrom (2009) proposes

[10]Dryer assumes a more complicated crosslinguistic typology of object functions than is generally accepted in LFG. His richer typology turns out to be best explained in terms of different strategies for relating thematic roles to object grammatical functions, as described in Chapter 9.

that certain verb stems in the Algonquian language Meskwaki subcategorize for a SUBJ and an OBJ$_\theta$. Dahlstrom shows that the OBJ$_\theta$ argument of these verbs does not share properties with OBJ; for instance, it cannot undergo lexical processes such as antipassivization (which suppresses an OBJ argument), and it does not trigger agreement on the verb. In both Turkish and Meskwaki, the verbs involved are lexically specified as taking an OBJ$_\theta$ argument. As Dahlstrom (2009) points out, these data provide evidence in favor of retaining OBJ and OBJ$_\theta$ as distinct grammatical functions, contrary to the possibility raised by Börjars and Vincent (2008) of collapsing the two. Dalrymple and Nikolaeva (2011) also rely on the OBJ/OBJ$_\theta$ distinction in their work on differential object marking and information structure. Based on data from a range of languages, Dalrymple and Nikolaeva (2011) claim that in certain languages a monotransitive predicate can take either a topical OBJ argument or a nontopical OBJ$_\theta$; that is, the argument is either OBJ or OBJ$_\theta$ depending on the argument's information structure role.[11] Without the distinction between OBJ and OBJ$_\theta$, this generalization would be lost. Maintaining the distinction between these two grammatical functions therefore appears to be justified.

1.7. COMP, XCOMP, and XADJ

The COMP, XCOMP, and XADJ functions are clausal functions, differing in whether they contain an overt SUBJ noun phrase. The COMP function is a *closed* function containing an internal SUBJ phrase. The XCOMP and XADJ functions are *open* functions that do not contain an internal subject phrase; their SUBJ must be specified externally to their phrase.[12]

(51) Open and closed functions:

$$\underbrace{\text{SUBJ OBJ OBJ}_\theta\text{ COMP OBL}_\theta\text{ ADJ}}_{\text{CLOSED}} \quad \underbrace{\text{XCOMP XADJ}}_{\text{OPEN}}$$

The COMP function is the function of clausal complements, familiar from traditional grammatical description. A COMP can be declarative, interrogative, or exclamatory (Quirk et al. 1985):

(52) a. *David complained that Chris yawned.*

b. *David wondered who yawned.*

c. *David couldn't believe how big the house was.*

[11] Chapter 10 discusses information structure and the distinction between topics and non-topics.

[12] Arka and Simpson (1998, 2008) propose that some control constructions in Balinese involve an open SUBJ function XSUBJ: for instance, in the Balinese equivalent of *I tried to take the medicine*, the infinitive phrase *to take the medicine* can bear the SUBJ function, with its SUBJ controlled by the term argument *I*. Falk (2005) presents an alternative analysis of the relevant data based on his proposal that, as well as XCOMP, two other governable grammatical functions exist: XOBJ$_\theta$ and XOBL$_\theta$. We do not explore either of these alternatives further here.

The XCOMP function is an open complement function, the one borne by a phrase like *to yawn* in the examples in (53). In those examples, the SUBJ of the XCOMP is also an argument of the matrix verb; in both of the examples in (53), it is *David*:

(53) a. *David seemed to yawn.*

b. *Chris expected David to yawn.*

Like XCOMP, the XADJ function is an open function, whose SUBJ must be specified externally; unlike XCOMP, XADJ is a modifier, not a governable grammatical function. In example (54), the SUBJ of the XADJ *stretching his arms* is also the SUBJ of the matrix clause, *David*:

(54) *Stretching his arms, David yawned.*

We will return to a discussion of XCOMP, XADJ, and control in Chapter 15.

There is ongoing debate concerning the status of the grammatical function COMP. Discussion centers on whether the COMP function can be discarded; proponents of this position argue that sentential complements can be analyzed instead as bearing the same types of grammatical function as nominal complements, and that therefore a specific function for clausal complements is not motivated. Three stances can be found in the literature: all clausal complements have the grammatical function COMP (Kaplan and Zaenen 1989a; Bresnan et al. 2016); clausal complements have the same grammatical functions as their nominal or adpositional counterparts, and COMP should be eliminated from the inventory (Alsina et al. 1996, 2005; Berman 2003; Forst 2006); and COMP should be retained in order to account for the differences in the syntactic behavior of some clausal complements in some languages (Dalrymple and Lødrup 2000; Berman 2007). In seeking to reanalyze some or all instances of COMP, the second and third approaches must show that clausal complements analyzed as objects or obliques exhibit syntactic properties characteristic of nominal objects or adpositional obliques.

Dalrymple and Lødrup (2000) propose to reclassify certain COMPS as OBJ, but argue that COMP should not be eliminated from the inventory of grammatical functions. They observe that there are phenomena that can only be explained by assuming the existence of the grammatical function COMP as distinct from OBJ. First, if all sentential complements are OBJ and not COMP, they would be classified as terms. In this case, the evidence presented in Section 1.3 of this chapter, indicating that English has clausal complements that are not terms, would remain unexplained. Second, if English clausal complements are analyzed as objects, then we must assume that English admits sentences with three OBJ functions, but only when one of the OBJ functions is sentential rather than nominal:

(55) *David bet [Chris] [five dollars] [that she would win].*

Most importantly, there is evidence for a split in the syntactic behavior of clausal complements in a number of languages; as discussed by Dalrymple and Lødrup (2000), this evidence is best explained by analyzing some clausal complements in these 'mixed languages' as OBJ, and some as COMP.

For example, in Swedish, the clausal complement of a verb such as *antar* 'assumes' bears the OBJ function; it can be pronominalized and can topicalize, as shown in examples (56a–c) from Engdahl (1999):

(56) a. *Man antar att sossarna vinner valet.*
one assumes that social.democrats.DEF win election.DEF
'One assumes that the Social Democrats will win the election.'

b. *Man antar det.*
one assumes that
'One assumes that.'

c. *[Att sossarna vinner valet] antar man.*
that social.democrats.DEF win election.DEF assumes one
'That the Social Democrats will win the election, one assumes.'

In contrast, the complement clause of a Swedish verb such as *yrkade* 'insisted' bears the COMP function, and does not display these properties:

(57) a. *Kassören yrkade att avgiften skulle höjas.*
cashier.DEF insisted that tax.DEF should be.increased
'The cashier insisted that the tax should be increased.'

b. **Kassören yrkade det.*
cashier.DEF insisted that
'The cashier insisted it.'

c. **[Att avgiften skulle höjas] yrkade kassören.*
That tax.DEF should be.increased insisted cashier.DEF
'That the tax should be increased, the cashier insisted.'

As Dalrymple and Lødrup (2000) show, other languages also show a similar split in the behavioral properties of clausal complements, with some clausal complements patterning with nominal OBJ arguments and others exhibiting behavior typical of COMP arguments. Thus, they argue, the COMP grammatical function cannot be eliminated from grammatical description, since many clausal complements must be analyzed as bearing the COMP function.

By contrast, Alsina et al. (2005) present data from Spanish, Catalan and Malayalam in support of discarding COMP entirely and instead reinterpreting clausal complements as having one of the grammatical functions OBJ, OBJ_θ, or OBL_θ.[13] According to this approach, any difference between non-clausal and clausal complements bearing the same grammatical function follows solely from their difference in phrase structure category. In support of this claim, Alsina et al. (2005) argue that there are syntactic differences among clausal complements that are not accounted for on Dalrymple and Lødrup's view. For instance, in Catalan it is necessary to distinguish two types of clausal complements which alternate with different pronominal clitics, *en* or *hi*, as shown in examples (58) and (59):

[13]In their analysis of control phenomena in Balinese, Arka and Simpson (2008) make a similar proposal in relation to XCOMP.

(58) a. *M' heu de convèncer que torni a casa.*
me have.2PL to convince that return.1SG to home
'You have to convince me to return home.'

b. *Me n' heu de convèncer.*
me EN have.2PL to convince
'You have to convince me of that.'

(59) a. *Estàvem d' acord que ens apugessin el sou.*
were.1PL of agreement that us raised.3PL the salary
'We agreed that they should raise our salary.'

b. *Hi estàvem d' acord.*
HI were.1PL of agreement
'We agreed on that.'

An analysis relying on the grammatical function COMP would fail to capture the similarities between these predicates when they take clausal complements (without a preposition) and when they select a particular preposition with a nominal complement (*de* or *en*), as shown in (60). Instead, each verb would have to be associated with two different subcategorization frames: one for COMP clausal complements, and the other for OBL_θ prepositional phrases.

(60) a. *M' heu de convèncer de les seves possibilitats.*
me have.2PL to convince of the 3GEN possibilities
'You have to convince me of his possibilities.'

b. *Estàvem d' acord en alguns punts.*
were.1PL of agreement on some points
'We agreed on certain points.'

Alsina et al. (2005) claim that the shared properties of the complements of such verbs are best captured by an analysis which treats them all as having the same grammatical function, OBL_θ. The result is a significant simplification, as each verb has a single subcategorization frame and redundancy is reduced: *convèncer* 'convince' subcategorizes for sentential or prepositional OBL_{de}, and *estar d'acord* 'agree' subcategorizes for sentential or prepositional OBL_{en}.

The status of COMP is still poorly understood. Dalrymple and Lødrup (2000) provide data which indicate that COMP and OBL_θ behave differently in a number of respects in German, and cannot be collapsed: COMP clauses cannot be topicalized, while OBL_θ phrases can; COMP clauses cannot appear in the middle field, while OBL_θ phrases can; and COMP phrases cannot be coordinated with OBL_θ phrases. In contrast, Forst (2006) discusses data which indicate that German complement clauses are best analyzed as bearing one of the grammatical functions OBJ, OBL_θ, or OBJ_θ, and that the COMP grammatical function is not needed in German. Lødrup (2012) provides a new argument for the relevance of COMP, arguing that the COMP grammatical function is needed not only in the analysis of clausal complements, but also for certain nominal complements in Norwegian: that is, that there are nominal as well as clausal COMPS. Until convincing arguments can be made that all COMPs in languages such as English, German, and Norwegian can be reanalyzed in terms of other grammatical functions, COMP cannot be abandoned on the basis of being redundant.

1.8. PREDLINK

PREDLINK is a closed grammatical function originally introduced by Butt et al. (1999) to analyze predicative constructions that include a linking or copular verb, such as those in (61).

(61) a. *Fiona is a nurse.*
b. *The book is red.*
c. *The vase is on the table.*
d. *The problem is that they yawned.*

According to this analysis, the copular predicate in these examples selects for a SUBJ and a PREDLINK. PREDLINK has also been employed in the analysis of some verbless sentences that express similar meanings to the examples in (61) (see Attia 2008). Under such an analysis, annotations on the phrase structure rules supply the main predicate, a proposal with its roots in the work of Rosén (1996).

The PREDLINK analysis can be contrasted with the traditional approach, which assumes that the copular predicate selects XCOMP, an open argument whose SUBJ is specified externally to the phrase. The XCOMP analysis is problematic in those cases where the constituent identified as the XCOMP does not otherwise appear to have an internal subject phrase, or has a different subject from that of the copular predicate. This is the case with noun phrases (61a), adjective phrases (61b), prepositional phrases (61c), and especially with clauses (61d). As Butt et al. (1999, page 70) point out, if the XCOMP analysis is to be maintained for all predicative constructions, it is necessary to assume that a phrase belonging to one of the relevant categories, such as *a nurse* in (61a), has two sets of subcategorization requirements depending on whether it is being used predicatively, and thus selects a SUBJ argument, as in (61a), or not. Under a PREDLINK analysis, no such issue arises because PREDLINK is a closed function — all of its relevant grammatical dependents are included; none are externally specified.

However, when it can be argued that the subjects of both the copula and the non-verbal complement are the same, for instance when the post-copular complement exhibits agreement with the subject of the main predicate as in the French examples in (62), an XCOMP analysis has been argued to capture the relation between the two in a more straightforward manner.[14]

(62) a. *Elle est petite.*
she.F.SG is small.F.SG
'She is small.'

[14] See Dalrymple et al. (2004a) and Attia (2008) for a different perspective.

b. *Il* *est petit.*
he.M.SG is small.M.SG
'He is small.'

The question of whether a PREDLINK or an XCOMP analysis is most appropriate for copular constructions, both within a particular language and crosslinguistically, has been the focus of attention in subsequent work. Those who propose a unified PREDLINK analysis, and thus seek to capture the functional equivalence of copular-type constructions at the level of functional structure, include Butt et al. (1999), Attia (2008) and Sulger (2011). In this book, we adopt a programmatic approach that aims to capture the ways in which such constructions are diverse, following Falk (2004), Nordlinger and Sadler (2007), and Laczkó (2012). Further discussion of copular constructions is provided in Chapter 5, Section 4.5.

1.9. Oblique Arguments: OBL$_\theta$

Oblique arguments are those that are associated with particular thematic roles and marked to indicate their function overtly. In languages like English, oblique arguments are prepositional phrases, while in other languages, as discussed by Nordlinger (1998), oblique arguments are casemarked rather than appearing as prepositional or postpositional phrases.

LFG assumes that there are two types of oblique arguments (Bresnan 1982a). Arguments of the first type are marked according to the thematic role of the argument, such as the goal *to*-phrase of a verb such as *give*. This class corresponds to the category of *semantic case* in the casemarking classification scheme of Butt and King (2004b), since semantic case is governed by generalizations about the relation between case and thematic role.

Arguments of the second type are marked idiosyncratically, and their form is lexically specified by the governing predicate. This class corresponds to the category of *quirky case* in Butt and King's classification scheme; see Section 5.7.5.

1.9.1. Semantically Marked Obliques

The phrase *to Chris* in example (63) bears the OBL$_{\text{GOAL}}$ grammatical function:

(63) *David gave the book <u>to Chris</u>.*

The thematic role of the OBL$_{\text{GOAL}}$ argument is marked by the preposition *to*. It is not possible for more than one oblique argument to have the same thematic role:

(64) **David gave the book <u>to Chris</u> <u>to Ken</u>.*

In languages like Warlpiri, an OBL$_{\text{LOC}}$ phrase such as *kirri-ngka* 'large camp' is marked with locative casemarking rather than a preposition or postposition (Simpson 1991; Nordlinger 1998):

(65) *<u>kirri-ngka</u>* *wiri-ngka-rlipa* *nyina-ja*
large.camp-LOC big-LOC-1PL.INCL.SUBJ sit-PST

'We sat in the large camp.'

Locative casemarking plays a similar role to the preposition in example (64), to mark the thematic role of the argument.

1.9.2. Idiosyncratic Prepositional Marking

An oblique phrase may also be required to bear a particular form unrelated to the thematic role of the argument. For such cases, Bresnan (1982a) suggests the presence of a FORM feature that is specified by the predicate. For example, in (66) the form of the preposition *on* in the phrase *on David* is stipulated by the predicate *relied*, which requires a semantically restricted nonterm argument: OBL_{ON}.

(66) *Chris relied on/*to/*about David.*

Butt et al. (1999) provide more discussion of oblique phrases with idiosyncratic prepositional marking.

1.10. POSS

We follow Bresnan et al. (2016) and many others in analyzing the genitive phrase which appears in the prenominal position in an English nominal phrase as bearing the grammatical function POSS:[15]

(67) *Chris's book*

The grammatical function POSS is the most prominent grammatical function associated with nominals, just as the SUBJ function is the most prominent clausal function. Similarities between POSS and SUBJ have often been noted, particularly in the realization of arguments of finite clauses and their corresponding gerunds and derived nominals (Chomsky 1970):

(68) a. *John criticized the book.*
 b. *John's criticizing the book*
 c. *John's criticism of the book*

Like the SUBJ function, arguments with the POSS function can bear any of a number of semantic roles, including possessor (as in example 67), agent (as in examples 68b,c), and other roles. POSS arguments often share other syntactic characteristics of subjects: for example, POSS and SUBJ often behave similarly with respect to anaphoric binding constraints. In Section 1.5, we saw that an identifying characteristic of subjects in Hindi is their inability to serve as the antecedent of a pronoun in the same clause. This was shown in example (32), repeated here:

[15] Dalrymple (2001) analyzes prenominal genitives as SPEC rather than POSS. We do not adopt that analysis here, though we will make use of the feature SPEC as a feature of nominal f-structures: see Section 5.7 for a discussion of the functional features of nominal phrases, including DEF and SPEC.

(69) *Vijay ne Ravii ko uskii saikil par biṭhaayaa*
Vijay ERG Ravi ACC his bicycle LOC sit.CAUS.PRF
'Vijay$_i$ seated Ravi$_j$ on his$_{*i,j,k}$ bike.'

As observed by Ghulam Raza (p.c.), the same constraints hold of POSS in the noun phrase; in (70), coreference between the POSS pronoun *uskii* and the POSS *Vijay* is disallowed, though coreference with the non-POSS argument *Ravii* or another individual is allowed:

(70) *Vijay kaa Ravii ko uskii saikil kaa tohfaa*
Vijay GEN Ravi DAT his bicycle GEN gift
'Vijay$_i$'s gift to Ravii$_j$ of his$_{*i,j,k}$ bike'

Sulger (2015) provides additional evidence showing that possessors exhibit subject-like properties in Hindi-Urdu. For example, Mohanan (1994) shows that the antecedent of the Hindi possessive reflexive *apnaa/apnii* must be a logical or grammatical subject, and cannot be a nonsubject:

(71) a. *Ravii apnii saikil par baiṭhaa*
Ravi self.GEN bicycle LOC sit.PRF
'Ravi$_i$ sat on self's$_{i,*j}$ bike.'

b. *Vijay ne Ravii ko apnii saikil par biṭhaayaa*
Vijay ERG Ravi ACC self.GEN bicycle LOC sit.CAUS.PRF
'Vijay$_i$ seated Ravi$_j$ on self's$_{i,*j,*k}$ bike.'

As Sulger shows, possessors are also able to bind reflexives within the nominal phrase:

(72) a. *meraa apnaa makaan*
my self.GEN house
'my$_i$ own$_i$ house'

b. *sadr kaa ilekšan karaane kaa apnaa elaan*
president GEN election do.CAUS GEN self.GEN announcement
'the announcement made by the president$_i$ himself$_i$ to conduct elections'

Indeed, Chisarik and Payne (2003) and Sulger (2015) analyze possessor arguments as SUBJ rather than POSS, arguing that this provides a more adequate and general picture of nominal and clausal syntactic relations. Laczkó (1995) discusses similarities between SUBJ and POSS in Hungarian, though he does not argue for collapsing the distinction between the two; see Falk (2002a) for additional arguments in favor of maintaining a distinction between SUBJ and POSS.

Bresnan et al. (2016, page 242) propose that POSS is a governable grammatical function for nominals, appearing in the argument list of the semantic form of the nominal. On this view, most or all nouns are ambiguous, either requiring (73a) or disallowing (73b) a POSS phrase:

(73) a. *Chris's book*

b. *the book*

We follow Bresnan et al. (2016, pages 315–316) in treating POSS as a derived argument, in the sense of Needham and Toivonen (2011); for discussion of derived arguments, see Chapter 9, Section 10.5.2.

Some languages have more than one way of expressing the possession relation within the noun phrase. For example, the possessor in English can be expressed either by a prenominal genitive or by a postnominal *of*-phrase; these are sometimes referred to as "short" and "long" possessive phrases (Falk 2002a), or as "genitive" and "*of*-oblique" possessors (Chisarik and Payne 2003):

(74) a. *the linguist's house*

b. *the house of the linguist*

In English, it is the short-form, prenominal genitive phrase, the phrase in (74a), which bears the POSS function and shares syntactic properties with SUBJ. The long-form postnominal phrase shares syntactic properties with clausal oblique phrases, and we treat such phrases as a kind of OBL.[16] Other languages may differ from English in the syntactic expression of possessors: see Laczkó (1995, 2004) and Chisarik and Payne (2003) for a discussion of the syntax of possession in Hungarian, Sadler (2000) for Welsh, Falk (2001a, 2002a) for Hebrew, and Sulger (2015) for Hindi-Urdu.

1.11. Overlay Functions

Each of the functions that we have discussed so far specifies the syntactic relation of an argument to a local predicate. However, as Falk (2001b, page 59) reminds us, clauses and the syntactic elements of which they are comprised do not exist in isolation; they are a part of larger syntactic and discourse structures to which they may be linked in a variety of ways. Falk refers to the set of secondary functions which a syntactic element may have as *overlay functions* (following Johnson and Postal 1980); in contrast, the primary functions already introduced are nonoverlay functions. An overlay function must be integrated into the structure of a clause via a primary, nonoverlay function, hence the term. The one overlay function that we assume in this book is DIS, which can be thought of as

[16] Chisarik and Payne (2003) present arguments in favor of analyzing these as a new grammatical function NCOMP; we do not adopt this analysis here.

standing for DIslocation or long DIstance dependency.[17] We use this overlay function in the analysis of long-distance dependencies and instances of dislocation.

An unbounded or long-distance dependency is the relationship that exists between a filler and a gap in, for example, the constituent questions in (75). In each of these sentences, the question word *what* appears in sentence-initial position and is the filler, while the gap to which it is related has a grammatical function in either the same clause (75a) or a subordinate clause (75b). A gap corresponds to a primary argument or adjunct grammatical function. In these examples, the relevant nonoverlay function is OBJ because the question word refers to the item(s) purchased. The filler to which a gap is related has the overlay function DIS.

(75) a. *What did Charlie buy ___?*

b. *What do you think [Charlie bought ___]?*

Details of the analysis of long-distance dependencies can be found in Chapter 17.

A dislocation construction involves an anaphoric dependency between the dislocated constituent and a primary, nonoverlay function. The sentence in (76) exemplifies left dislocation in English.

(76) a. *Beans$_i$, Charlie likes them$_i$.*

b. *Beans$_i$, David thinks [Charlie likes them$_i$].*

In both (76a) and (76b) there is an anaphoric dependency between the left-dislocated constituent *Beans*, with the overlay function DIS, and the pronoun *them* with the primary function OBJ. Details of the analysis of anaphoric dependencies can be found in Chapter 14.

Some LFG work (Falk 2001b, for instance) has also treated SUBJ as being an overlay function, the only overlay function which is also an argument. However, this work predates Falk's major work on subjecthood (Falk 2006), discussed in Section 1.5, in which he proposes that SUBJ be abandoned and replaced with two separate functions: $\widehat{\text{GF}}$ and PIVOT. $\widehat{\text{GF}}$ is a primary (nonoverlay) governable grammatical function, while PIVOT is a secondary overlay function. This approach has the advantage of eliminating from the original set of grammatical functions the only overlay function that is an argument, SUBJ. We use SUBJ rather than $\widehat{\text{GF}}$ or PIVOT in this book (see Section 1.5), but we follow Falk (2001b) in classifying SUBJ as a primary nonoverlay grammatical function.

[17] In much LFG work, including Bresnan and Mchombo (1987), Dalrymple (2001), Falk (2001b), and Bresnan et al. (2016), the syntacticized discourse functions TOPIC and FOCUS are used as overlay functions. However, this approach has been rejected as inadequate in other work on displaced constituents, notably by Alsina (2008), who proposes an overlay feature OP ("operator") instead of discourse functions like TOPIC and FOCUS, and Asudeh (2004, 2011, 2012), who proposes an overlay feature UDF ("unbounded dependency function"). We use the feature DIS rather than OP or UDF: the term "unbounded dependency" generally refers to the relation between a filler and a gap, as in example (75) but not example (76), and the term "operator" is widely used in semantics but with a different (though related) meaning.

Falk (2006, page 74) proposes that PIVOT is an overlay function which relates elements which are 'shared' between clauses, defining PIVOT as "the element with the function of connecting its clause to other clauses in the sentence". Like the overlay function DIS, a syntactic element with the function PIVOT must be identified with a primary function; see Falk (2006) for details. To give an example, in Dyirbal (Dixon 1994, page 15) PIVOT is invariably identified with either the intransitive subject or the transitive object; in (77), the PIVOT OBJ of the verb *bura* 'see' in the first clause is identified with the PIVOT $\widehat{\text{GF}}$ of the verb *banaga* 'return' second clause.

(77) *N^{y}urra ŋana-na bura-n banaga-n^{y}u*
2PL.NOM 1PL.ACC see-NFUT return-NFUT
'You saw us and (we) returned.'

Falk (2006) speculates that not all languages make use of the function PIVOT; as noted in Section 1.5, Choctaw/Chickasaw and Warlpiri seem to be pivotless languages, lacking pivot-sensitive constructions such as long-distance dependencies and functional control constructions.

As mentioned in Section 1.5, we set aside PIVOT in this book. The only overlay function we employ is DIS.

2. THE AUTONOMY OF FUNCTIONAL ORGANIZATION

LFG does not assume that abstract grammatical functions are defined in terms of their phrase structural position in the sentence or in terms of morphological properties like casemarking; instead, grammatical functions are primitive concepts of the theory. However, there is also clear evidence for structure at other levels: for example, there is abundant evidence for morphological and phrasal organization and structure. Given this, one might conclude that constituent structure is the only structure with a firm linguistic basis, and that the appearance of abstract grammatical functions is actually only an illusion. On this view, the generalizations assumed by traditional grammarians are actually derivative of phrasal organization and structure. We will see in the following that this view is misguided: attempts to define functional structure in terms of morphological or phrase structure concepts do not succeed.

2.1. Grammatical Functions Defined?: Casemarking

It is clear that arguments of predicates have certain superficial morphological properties, and it is equally clear that it is not possible to provide a simple definition of grammatical functions in terms of these properties. A cursory look at languages with complex casemarking systems is enough to show that the relation between case and grammatical function is not at all straightforward.

Examples given in Section 1.6 of this chapter show that it is possible to demonstrate a correlation between grammatical function and casemarking in Malayalam: if an argument is ACC, it is an object. However, the overall picture is much more complex, and Mohanan (1982) argues convincingly against defining grammatical functions in terms of superficial properties like case. Objects in Malayalam are marked ACC if animate and NOM if inanimate:

(78) a. Nominative subject and object:

kuṭṭi waatil aṭaccu
child.NOM door.NOM closed

'The child closed the door.'

b. Nominative subject, accusative object:

kuṭṭi aanaye kaṇṭu
child.NOM elephant.ACC saw

'The child saw the elephant.'

In Malayalam, then, there is clearly no one-to-one relation between casemarking and grammatical function, since a grammatical function like OBJ is not always marked with the same case.

Similarly, arguments that can be shown to bear the SUBJ function in Icelandic are marked with a variety of cases, as shown by Andrews (1982). These cases also appear on arguments filling nonsubject grammatical functions; for instance, as examples (79a) and (79b) show, ACC case can appear on both subjects and objects, and examples (79c) and (79d) show that subjects can bear other cases as well:

(79) a. Accusative subject:

Hana dreymdi um hafið.
She.ACC dreamed about sea
'She dreamed about the sea.'

b. Accusative object:

Stúlkan kyssti drengina.
girl.NOM kissed boys.ACC
'The girl kissed the boys.'

c. Dative subject:

Bátnum hvolfdi.
boat.DAT capsized
'The boat capsized.'

d. Genitive subject:

Verkjanna gætir ekki.
pains.GEN is.noticeable not
'The pains are not noticeable.'

In sum, the relation between grammatical function and case is complex. Even when there is a close relation between case and grammatical function, as discussed in Section 1.6 of this chapter, a clear and explanatory description of case-marking and other morphosyntactic properties is best obtained by reference to abstract functional properties.

2.2. Grammatical Functions Defined?: Constituent Structure

Another visible, easily testable property of languages is their surface phrase structure. Given the necessity for this structure, one might claim that grammatical functions are not universally manifest, but instead that the appearance of grammatical functions in a language like English is due to the fact that grammatical functions are associated with certain phrasal configurations in English syntax: in a nutshell, English has subjects and objects because English is *configurational*. This claim entails that languages that are not configurational would not be expected to exhibit the same abstract functional relations.[18]

Warlpiri is a language whose phrasal syntactic structure is completely different from that of languages like English. Warlpiri (like many Australian languages) is known for displaying "nonconfigurational" properties, including free word order and "discontinuous phrases". The following Warlpiri sentences involve permutations of the same words; they are all grammatical and have more or less the same meaning (Hale 1983, page 6):

[18] For in-depth discussion of configurationality in an LFG setting, see Snijders (2015).

(80) a. *ngarrka-ngku ka wawirri panti-rni*
man-ERG AUX kangaroo spear-NPST
'The man is spearing the kangaroo.'

b. *wawirri ka panti-rni ngarrka-ngku*
kangaroo AUX spear-NPST man-ERG

c. *panti-rni ka ngarrka-ngku wawirri*
spear-NPST aux man-ERG kangaroo

It would be difficult to find a language less like English in its phrase structure configurational properties. Thus, Warlpiri would seem to be a good candidate to test the hypothesis that evidence for grammatical functions can be found only in English-like configurational languages.

However, as Hale (1983) demonstrates, languages like Warlpiri do show evidence of abstract grammatical relations, just as English-like configurational languages do. Hale discusses person marking, control, and interpretation of reflexive/reciprocal constructions, showing that constraints on these constructions are not statable in terms of surface configurational properties. Simpson and Bresnan (1983) and Simpson (1991) provide further evidence that properties like control in Warlpiri are best stated in terms of abstract functional syntactic relations. In particular, Simpson and Bresnan (1983) examine the *karra*-construction, in which the subject of a subordinate clause with subordinate clause affix *karra* is controlled by the subject of the matrix clause:

(81) *ngarrka ka wirnpirli-mi [karli jarnti-rninja-karra]*
man.ABS AUX whistle-NPST boomerang.ABS trim-INF-COMP
'The man$_i$ is whistling while (he$_i$ is) trimming a boomerang.'

As Simpson and Bresnan show, the controller subject may be discontinuous or absent, and it may be marked with NOM, ABS, or ERG case. The correct generalization about this construction involves the abstract grammatical function SUBJ of the controller, not its case or its surface configurational properties.

Thus, even in a language that appears to have completely different phrase structure properties from English, and which has been analyzed as "nonconfigurational", evidence for abstract functional syntactic relations is still found. The hypothesis that functional structure is epiphenomenal of surface configurational properties is not viable.

2.3. Grammatical Functions Defined?: Semantic Composition

Dowty (1982) proposes to define grammatical functions like SUBJ and OBJ in compositional semantic terms, by reference to order of combination of a predicate with its arguments: a predicate must combine with its arguments according to a functional obliqueness hierarchy, with the SUBJ defined as the last argument to combine with the predicate. This approach is also adopted by Gazdar et al. (1985) for Generalized Phrase Structure Grammar, and has to some extent carried over to Head-Driven Phrase Structure Grammar (Pollard and Sag 1994; Sag et al. 2003).

There are several ways in which an approach like Dowty's, where grammatical functions are defined as an ordering on the arguments of a predicate, might lead to incorrect predictions. First, if the order of semantic composition is very closely tied to the order of composition of the surface configurational structure, this approach would predict that the subject could not intervene between the verb and the object; of course, this prediction is not correct, since many languages exhibit VSO word order. The theory that Dowty and most other adherents of this position advocate does not suffer from this difficulty, however, since the hypothesized relation between the surface order of arguments in a sentence and the order of semantic composition is more complex.

A more subtle problem does arise, however. It is not clear that such an approach can make certain distinctions that are necessary for syntactic analysis: in particular, it does not seem possible to distinguish between predicates that take the same number of arguments with the same phrasal categories. For example, any two-argument verb that requires a nominal subject and a clausal complement should behave like any other such verb. However, it has been claimed that there are languages in which some clausal complements bear the OBJ function, while others bear the COMP function, as discussed in Section 1.7 of this chapter. In a theory like LFG, this distinction is reflected in a difference in the grammatical function of the complement; some complements are OBJ, and others are COMP. However, it is not clear how such a distinction can be made in a theory that does not allow explicit reference to grammatical functions.

Dowty (1982, page 107) also argues against theories which, like LFG, assume that grammatical functions are undefined primitives by claiming that in his approach "grammatical relations play an important role in the way syntax relates to compositional semantics." This statement is a non sequitur. In LFG, grammatical functions are primitive concepts and also play an important role in compositional semantics and the syntax-semantics interface. Indeed, this is the topic of Chapter 8 and the following chapters (see also Bresnan 1982a, page 286).

Leaving aside these difficulties, there is a strong degree of similarity between theories that define grammatical functions in terms of abstract properties such as order of semantic combination and theories like LFG, in which grammatical functions are not definable in terms of phrasal or argument structure. For both types of theories, grammatical functions are abstract and are analyzed independently from phrasal and other structures.

3. SUBCATEGORIZATION

At a minimum, the idiosyncratic information that must be specified for a word is its pronunciation and its meaning. Research has shown that the syntactic behavior of a word can be partially predicted from its meaning; this is because a number of regularities govern the relation between the meaning of a predicate and the grammatical functions of its arguments, as we discuss in detail in Chapter 9. LFG and other linguistic theories define and capitalize on this relation in their theory of syntactic subcategorization.

LFG assumes that syntactic subcategorization requirements of predicates are stated at the f-structure level, in functional rather than phrasal terms. Predicates require a set of arguments bearing particular thematic roles. These roles are associated with grammatical functions according to a theory of argument mapping, to be discussed in Chapter 9. In turn, these grammatical functions are realized at the level of constituent structure in a variety of ways, as required by particular languages: in some languages, grammatical functions are associated with particular phrase structure positions, while in other languages, grammatical functions may be signaled by particular kinds of morphological marking on the head or on the argument (see Chapter 5, Section 4).

In contrast to this view, and in line with some proposals in transformational grammar (Chomsky 1965), some linguistic theories state subcategorization requirements in terms of phrase structure positions rather than abstract functional syntactic organization: in such theories, for example, a transitive verb in English is defined as a verb that must be followed by a noun phrase object. There are many reasons to question the viability of this position, since the bulk of phrase structure information is never relevant to the satisfaction of subcategorization requirements. As Grimshaw (1982b) points out, predicates never vary idiosyncratically in terms of which phrasal position they require their arguments to be in; for example, there are no exceptional transitive verbs in English which require their objects to appear preverbally rather than postverbally. Subcategorization according to constituent structure configuration rather than functional structure leads to the incorrect expectation that such exceptional verbs should exist. In fact, however, we can cleanly state subcategorization requirements in terms of abstract functional structure; the claim that all phrasal and configurational information is always relevant to subcategorization is too strong.

There is evidence that one particular type of constituent structure information may in some cases be relevant to subcategorization requirements: cases in which a predicate idiosyncratically requires an argument of a particular phrasal category. Other kinds of phrasal information, such as position, never play a role in subcategorization requirements. However, one must take care in identifying situations in which such requirements seem to hold. Often, as Maling (1983) demonstrates, apparent evidence for subcategorization for a particular phrase structure category turns out on closer examination to be better analyzed as a requirement for an argument of a particular semantic type, together with a strong correlation between that type and the particular phrasal category most often used to express it. Maling notes that predicates like *seem* have often been claimed to require adjective phrase complements and to disallow prepositional phrase complements:

(82) a. *Sandy seems clever.*

b. **Sandy seems out of town.*

However, Maling shows that the true criterion at work in these examples is not based on phrase structure category, but is semantic in nature: only *gradable predicates*, those that can hold to a greater or lesser degree, are acceptable as complements of *seem* (see also Bresnan et al. 2016, Chapter 12, and references cited there). Many prepositional phrases do not express gradable predicates, accounting for the unacceptability of example (82b). However, prepositional phrases that denote gradable predicates are acceptable as complements of *seem*:

(83) a. *That suggestion seemed completely off the wall.*

b. *Lee sure seems under the weather.*

Further, as Maling shows, adjective phrases that are not gradable predicates are unacceptable as complements of *seem*. In the following examples, the adjective *irrational* as a description of a mental state is gradable and can be used as the complement of *seems*, while as a technical mathematical term it is not gradable and cannot be used:

(84) a. *Lee seems irrational.*

b. **The square root of two seems irrational.*

In some cases, then, requirements that appear to depend on phrase structure category prove on closer inspection to be functional or semantic in nature.

In other cases, however, the particular constituent structure category of the complement is at issue, and no functional or semantic distinction is involved. The circumstances under which these extra specifications are necessary are rare: subcategorization for a particular phrasal category is a marked exception rather than the general rule. In Chapter 6, Section 10.3, we discuss these cases, showing that the phrase structure category of a complement can be specified in these limited cases.

4. FUNCTIONAL STRUCTURE REPRESENTATION

In LFG, functional information is formally represented by the *functional structure* or *f-structure*. Mathematically, the f-structure can be thought of as a function[19] from attributes to values, or equivalently as a set of pairs, where the first member of the pair is an attribute and the second is its value.[20] There is a simple

[19] A function is a special kind of relation which assigns a *unique* value to its argument. For example, the relation between a person and his or her age is a function, since every person has exactly one age. The relation between a person and his or her children is not a function, since some people have no children and some people have more than one child.

[20] We use the term *feature* as a synonym of *attribute*, so that *feature-value pair* and *attribute-value pair* mean the same thing. Bresnan et al. (2016) use the term *feature* in a way that differs from ours: for them, a feature is an attribute-value pair in which the value is simple, such as [DEF +] or [VTYPE FIN].

and common way of representing f-structures in tabular form, that is, as a table of attributes and values:[21]

(85) $$\left[\begin{array}{ll} \textsc{attribute}1 & \textsc{value}1 \\ \textsc{attribute}2 & \textsc{value}2 \end{array}\right]$$

4.1. Simple F-Structures

The following is a simplified f-structure for the noun phrase *the man*:

(86) $$\left[\begin{array}{ll} \text{PRED} & \text{‘MAN’} \\ \text{DEF} & + \end{array}\right]$$

This f-structure does not contain all the syntactic information that *the man* contributes. We assume here and elsewhere that the full f-structure representation for the examples we exhibit contains at least the information shown, but may also contain other information not relevant to the particular point under discussion.

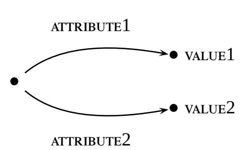
The f-structure in (86) contains two attributes: PRED and DEF. The value of DEF is $+$, indicating a positive value for the definiteness feature DEF. This is a simple *atomic* value, with no internal structure.

For the sentence *The man yawned*, we have the following f-structure:

(87) $$y\left[\begin{array}{ll} \text{PRED} & \text{‘YAWN}\langle\text{SUBJ}\rangle\text{’} \\ \text{TENSE} & \text{PST} \\ \text{SUBJ} & m\left[\begin{array}{ll} \text{PRED} & \text{‘MAN’} \\ \text{DEF} & + \end{array}\right] \end{array}\right]$$

As (87) shows, f-structures can themselves be values of attributes: here, the value of the attribute SUBJ is the f-structure for the subject of the sentence. We can annotate f-structures with labels for subsequent reference; in (87), we have annotated the SUBJ f-structure with the label *m* and the f-structure for the sentence with the

[21] In some literature, particularly in Head-Driven Phrase Structure Grammar (see, for example, Pollard and Sag 1994), the objects that are represented in LFG as structures like (85) are instead represented via diagrams such as:



Attributes are labeled arcs in the diagram, and values are nodes. A sequence of attributes, a *path* through the f-structure, corresponds to the traversal of several labeled arcs. A possible source of confusion for those trained within the Head-Driven Phrase Structure Grammar framework is that the same formal notation used to represent LFG functional structures in examples like (85) is used to represent *constraints* on structures in HPSG. What is depicted in (85) is not a constraint; it is a formal object.

label *y*. These labels are not a part of the f-structure, but provide a convenient way of referring to an f-structure and its parts.

4.2. Semantic Forms

The value of the PRED attribute is special: it is a *semantic form*. A full discussion of semantic forms will be presented in Chapter 5, Section 2.2; additionally, Chapter 8 presents a more complete discussion of the information that semantic forms represent. In example (87), the semantic form value of the PRED for the f-structure labeled *m* is 'MAN', and the value of the PRED attribute of *y* is 'YAWN⟨SUBJ⟩'. The single quotes surrounding a semantic form indicate *uniqueness*: each instance of use of the word *man* gives rise to a uniquely instantiated occurrence of the semantic form 'MAN'.

We use English names for semantic forms throughout. For example, we provide the semantic form 'MAN' for the Warlpiri noun *wati* 'man'. This is done for ease of readability and to emphasize the distinction between the semantic form associated with a word and its surface realization; uniform use of Warlpiri names instead of English ones for semantic forms would be equally satisfactory, though generally less clear for an English-speaking audience.

The list of grammatical functions mentioned in a semantic form is called the *argument list*. We discuss its role in determining wellformedness constraints on f-structures in Section 4.6 of this chapter. In (87), the argument list for the verbal predicate *yawn* indicates that it subcategorizes for a subject only.

It is not just verbs that have arguments, of course. A preposition which contributes semantic content has its own PRED value which includes an argument list. It forms a separate embedded f-structure with its argument, as shown in (88).

(88) *David fell from the chair.*

$$\left[\begin{array}{ll} \text{PRED} & \text{`FALL}\langle\text{SUBJ,OBL}_{\text{LOC}}\rangle\text{'} \\ \text{TENSE} & \text{PST} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`DAVID'}\end{array}\right] \\ \text{OBL}_{\text{LOC}} & \left[\begin{array}{ll} \text{PRED} & \text{`FROM}\langle\text{OBJ}\rangle\text{'} \\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`CHAIR'} \\ \text{DEF} & + \end{array}\right]\end{array}\right]\end{array}\right]$$

Compare this with a preposition such as *on* in (89), whose presence is required to mark the oblique argument of *relied*, but which makes no semantic contribution and does not have its own argument list:

(89) *David relied on Chris.*

$$\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{rely}\langle\textsc{subj},\textsc{obl}_{\textsc{on}}\rangle\text{’} \\ \textsc{tense} & \textsc{pst} \\ \textsc{subj} & \left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{David}\text{’} \end{array}\right] \\ \textsc{obl}_{\textsc{on}} & \left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{Chris}\text{’} \end{array}\right] \end{array}\right]$$

The f-structure representation of PPs is discussed further in Chapter 6, Section 2.

4.3. Attributes with Common Values

It is possible for two different attributes of the same f-structure to have the same value. When the value is an *atom* like + or M rather than an f-structure, we simply repeat the value each time:

(90)
$$\left[\begin{array}{ll} \textsc{attribute}1 & \textsc{v} \\ \textsc{attribute}2 & \textsc{v} \end{array}\right]$$

It is also possible for two different attributes to have the same f-structure as their value. Here the situation is slightly more complex. Recall that an f-structure is a set of pairs of attributes and values: f-structures, like other sets, obey the *Axiom of Extension*, which states that two sets are the same if and only if they have the same members (Partee et al. 1993, section 8.5.8). Thus, two f-structures are indistinguishable if they contain the same attribute-value pairs.[22]

Notationally, it is in some cases clearer to represent two identical f-structures separately, repeating the same f-structure as the value of the two attributes:

(91)
$$\left[\begin{array}{ll} \textsc{attribute}1 & \left[\begin{array}{ll} \textsc{a}1 & \text{v1} \\ \textsc{a}2 & \text{v2} \end{array}\right] \\ \textsc{attribute}2 & \left[\begin{array}{ll} \textsc{a}1 & \text{v1} \\ \textsc{a}2 & \text{v2} \end{array}\right] \end{array}\right]$$

Care must be taken if a *semantic form*, the value of the attribute PRED, is repeated. Since each instance of a semantic form is unique, a repeated semantic form must be explicitly marked with an index to indicate identity; see Chapter 5,

[22]This view of f-structures is different from the view of similar structures in Head-Driven Phrase Structure Grammar (Pollard and Sag 1994; Sag et al. 2003; Levine 2017); the attribute-value structures of HPSG are *graphs*, not set-theoretic objects. On the HPSG view, two attribute-value structures can contain the same attributes and values and can nevertheless be different structures. To state the same point in a different way: HPSG relies on a *type-token* distinction in attribute-value structures (Shieber 1986), meaning that two attribute-value structures are of the same *type* if they have the same set of attributes and values, but may be different *tokens* of that type. In the set-theoretic view of LFG, the Axiom of Extension precludes a type-token distinction, so two f-structures that have the same attributes and values are not distinguished.

Section 2.2.1 for more discussion of this point. If no such index appears, the two semantic forms are assumed to be different.

In other cases, it may be easier and more perspicuous not to repeat the f-structure, but to use other notational means to indicate that the same f-structure appears as the value of two different attributes. We can accomplish this by drawing a line from one occurrence to another, a common practice in LFG literature; this notation conveys exactly the same information as in (91):

(92)
$$\begin{bmatrix} \textsc{attribute}1 & \begin{bmatrix} \textsc{a}1 & \text{v}1 \\ \textsc{a}2 & \text{v}2 \end{bmatrix} \\ \textsc{attribute}2 & \end{bmatrix}$$

This convention is notationally equivalent to another common way of representing the same structure, using numbers enclosed in boxes:

(93)
$$\begin{bmatrix} \textsc{attribute}1 & \boxed{1}\begin{bmatrix} \textsc{a}1 & \text{v}1 \\ \textsc{a}2 & \text{v}2 \end{bmatrix} \\ \textsc{attribute}2 & \boxed{1} \end{bmatrix}$$

There is no substantive difference between these two conventions; following LFG tradition, we generally represent identical values for two attributes by drawing a line connecting the two values, as in (92).

4.4. Sets

Sets are also valid structures, and may appear as values of attributes. Sets are often used to represent structures with an unbounded number of elements.[23] For instance, there is in principle no limit to the number of modifiers that can appear with any phrase, and so the value of the ADJ attribute is the set of all modifiers that appear. Formally, sets are enclosed in curly brackets, with the elements of the set inside the brackets:

[23]The f-structure remains a function from attributes to values even if the value of an attribute is a set. A structure like (a), in which an attribute has a set with three members as its value, is a function, while a structure like (b), in which the same attribute has three different values simultaneously, is not a function.

(a) Function: $\begin{bmatrix} \textsc{attribute}1 & \left\{ \begin{bmatrix} \textsc{a}1 & \text{v}1 \end{bmatrix} \begin{bmatrix} \textsc{a}2 & \text{v}2 \end{bmatrix} \begin{bmatrix} \textsc{a}3 & \text{v}3 \end{bmatrix} \right\} \end{bmatrix}$

(b) Not a function: $\begin{bmatrix} \textsc{attribute}1 & \begin{bmatrix} \textsc{a}1 & \text{v}1 \end{bmatrix} \\ \textsc{attribute}1 & \begin{bmatrix} \textsc{a}2 & \text{v}2 \end{bmatrix} \\ \textsc{attribute}1 & \begin{bmatrix} \textsc{a}3 & \text{v}3 \end{bmatrix} \end{bmatrix}$

(94) *David yawned quietly.*

$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{yawn}\langle\textsc{subj}\rangle\text{’} \\ \textsc{tense} & \textsc{pst} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{‘David’} \end{bmatrix} \\ \textsc{adj} & \left\{ \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{quietly}\text{’} \end{bmatrix} \right\} \end{bmatrix}$$

In (94) only a single modifier appears, but other sentences may contain more modification:

(95) *David yawned quietly yesterday.*

$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{yawn}\langle\textsc{subj}\rangle\text{’} \\ \textsc{tense} & \textsc{pst} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{‘David’} \end{bmatrix} \\ \textsc{adj} & \left\{ \begin{matrix} \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{quietly}\text{’} \end{bmatrix} \\ \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{yesterday}\text{’} \end{bmatrix} \end{matrix} \right\} \end{bmatrix}$$

Any valid structure can be an element of a set: for example, some sets can have atomic values as their elements. As we discuss in Section 5.7, sets of atomic values have been used to represent the values of the PERS, GEND, and CASE attributes in analyses of feature resolution and feature indeterminacy.

4.5. Sets With Additional Properties

Since there is no limit to the number of coordinated elements in a coordinate structure, we also use sets in their representation, with the coordinated elements (the *conjuncts*) as members of the set. Thus, the f-structure of a coordinate structure like *David and Chris* is a set, and the f-structure for each of the conjuncts *David* and *Chris* is an element of the set, as shown in (97).

Sets representing coordinate structures are treated specially: coordinate structures are *hybrid objects*, sets that can have their own attributes and values as well as having elements.[24] Attributes which can be associated with a set are called *nondistributive features*, while attributes which cannot be associated with a set are called *distributive features*. We will return to a discussion of nondistributive features and the distributive-nondistributive distinction in Section 5.7 of this chapter, in Chapter 6, Section 3.2, and in our discussion of feature resolution in Chapter 16, Section 8.1.

As noted above, we represent sets in curly brackets that contain the element f-structures. If a set has additional nondistributive attributes, we enclose the set in square brackets and list the attributes and values of the set within the square

[24]The proposal to treat sets representing coordinate structures as hybrid objects is originally due to John Maxwell (p.c.), and is foreshadowed in work on coordination in LFG by Peterson (1982) and Andrews (1983a).

brackets. For example, if a set f has the nondistributive attribute a with value v it looks like this:

(96)
$$f\begin{bmatrix} a & v \\ \{ & \} \end{bmatrix}$$

In the following example, the conjuncts of the coordinate subject *David and Chris* are each singular (with the value SG for the NUM feature in the INDEX feature bundle) but the coordinate structure as a whole is a plural phrase. Thus, the set bears the nondistributive attribute INDEX with PL as the value for the NUM feature:[25]

(97) *David and Chris yawn.*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'} \\ \textsc{tense} & \textsc{prs} \\ \textsc{subj} & \begin{bmatrix} \textsc{index} & \begin{bmatrix}\textsc{num} & \textsc{pl}\end{bmatrix} \\ \left\{ \begin{matrix} \begin{bmatrix} \textsc{pred} & \text{`David'} \\ \textsc{index} & \begin{bmatrix}\textsc{num} & \textsc{sg}\end{bmatrix} \end{bmatrix} \\ \\ \begin{bmatrix} \textsc{pred} & \text{`Chris'} \\ \textsc{index} & \begin{bmatrix}\textsc{num} & \textsc{sg}\end{bmatrix} \end{bmatrix} \end{matrix} \right\} & \end{bmatrix} \end{bmatrix}$$

Notice that nondistributive attributes such as INDEX may appear as attributes of the conjuncts in a set as well as attributes of the set itself: in example (97), each of the conjuncts *David* and *Chris* has a singular INDEX value, while the set as a whole has a plural INDEX. In contrast, conjuncts can have distributive attributes like PRED, but a set cannot have a distributive attribute.

4.6. Wellformedness Conditions on F-Structures

F-structures are subject to certain wellformedness conditions: Completeness, Coherence, and Consistency (Kaplan and Bresnan 1982). The Completeness and Coherence conditions ensure that all the arguments of a predicate are present and that there are no additional arguments that the predicate does not require. The Consistency condition ensures that each attribute of an f-structure has a single value. We also discuss these requirements in Chapter 5, Section 2.2.

4.6.1. Completeness

The Completeness requirement tells us what is wrong with a sentence like:

(98) **David devoured.*

[25]We motivate a more complex representation of the number feature in Section 5; in this section we make the simplifying assumption that NUM has atomic values like SG (singular) and PL (plural).

Intuitively, some required material is missing from an f-structure that is incomplete.[26] The required material is specified as a part of the value of the PRED attribute, the semantic form. The PRED attribute and semantic form for a verb like *devoured* are:

(99) $\left[\text{PRED} \quad \text{‘DEVOUR}\langle\text{SUBJ,OBJ}\rangle\text{’}\right]$

The *argument list* of a semantic form is a list of *governable grammatical functions*[27] that are *governed*, or mentioned, by the predicate: in example (99), *devour* governs the grammatical functions SUBJ and OBJ. Example (98) contains a SUBJ but no OBJ; this accounts for its unacceptability according to the Completeness requirement.

Previous LFG literature has employed a variety of notations for the argument list. In the notation employed here, the argument list consists of a list of names of governable grammatical functions. In other work, the argument list is sometimes depicted as a list of f-structures which are the values of the subcategorized functions:

(100) *David devoured the cake.*

$$\left[\begin{array}{ll} \text{PRED} & \text{‘DEVOUR}\langle\underline{\quad},\underline{\quad}\rangle\text{’} \\ \text{TENSE} & \text{PST} \\ \text{SUBJ} & \left[\text{PRED} \quad \text{‘DAVID’}\right] \\ \text{OBJ} & \left[\begin{array}{ll} \text{PRED} & \text{‘CAKE’} \\ \text{DEF} & + \end{array}\right] \end{array}\right]$$

It is also common for the argument list to be represented in the following way, where ($\uparrow$ SUBJ) represents the subject f-structure and ($\uparrow$ OBJ) represents the object f-structure, as explained in Chapter 5, Section 3.1:

(101) *David devoured the cake.*

$$\left[\begin{array}{ll} \text{PRED} & \text{‘DEVOUR}\langle(\uparrow \text{SUBJ}), (\uparrow \text{OBJ})\rangle\text{’} \\ \text{TENSE} & \text{PST} \\ \text{SUBJ} & \left[\text{PRED} \quad \text{‘DAVID’}\right] \\ \text{OBJ} & \left[\begin{array}{ll} \text{PRED} & \text{‘CAKE’} \\ \text{DEF} & + \end{array}\right] \end{array}\right]$$

These notational variants are used equivalently, though technically the variant shown in (101) is incorrect, since it contains the uninstantiated f-structure metavariable $\uparrow$ (which we introduce in Chapter 5, Section 3.1); here, we choose the more

[26] Optional dependents (for example, instruments and benefactives) are discussed in Chapter 9, Section 10.5.2.

[27] Recall from Section 1.2 of this chapter that the governable grammatical functions are SUBJ, OBJ, OBJ_θ, OBL_θ, XCOMP and COMP.

succinct representation in (99) to save space and make the f-structures more readable.

There is a difference between grammatical functions that appear inside the angled brackets and those that appear outside. In (99), the functions SUBJ and OBJ are semantic as well as syntactic arguments of *devour*, contributing to its meaning as well as filling syntactic requirements. In contrast, the semantically empty expletive subject *it* of a verb like *rain* makes no semantic contribution — it is athematic. This intuitive difference is reflected in the formal requirement that arguments of a predicate that appear inside angled brackets must contain a PRED attribute whose value is a semantic form; this is not required for arguments outside angled brackets. Thus, the SUBJ function appears outside the angled brackets of the argument list of the semantic form of *rain*:

(102) *It rained.*

$$\left[\begin{array}{ll}\text{PRED} & \text{`RAIN}\langle\rangle\text{SUBJ'}\end{array}\right]$$

Similarly, the SUBJ argument of the verb *seem* is not a semantic argument of that verb and appears outside the angled brackets:

(103) *It seemed to rain.*

$$\left[\begin{array}{ll}\text{PRED} & \text{`SEEM}\langle\text{XCOMP}\rangle\text{SUBJ'}\end{array}\right]$$

Note that it is not a violation of any condition for more than one predicate to govern an f-structure with a semantic form. In fact, this is a common situation with "raising" verbs like *seem*, whose subject is also the subject of its XCOMP argument (see Chapter 15). Since the subject of *seem* is a syntactic but not a semantic argument of the *seem* predicate, the SUBJ in the value of the PRED attribute of *seem* appears outside the angled brackets.

(104) *David seemed to yawn.*

$$\left[\begin{array}{ll}\text{PRED} & \text{`SEEM}\langle\text{XCOMP}\rangle\text{SUBJ'}\\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`DAVID'}\end{array}\right]\\ \text{XCOMP} & \left[\begin{array}{ll}\text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'}\\ \text{SUBJ} & \end{array}\right]\end{array}\right]$$

The line connecting the f-structure for *David* to the SUBJ position of *seem* indicates that the same f-structure is the value of two different attributes, as discussed in Section 4.3 of this chapter: it is both the SUBJ of *seem* and the SUBJ of *yawn*. Completeness is satisfied for both predicates: each requires a SUBJ, and this requirement is satisfied for each verb.

Following Kaplan and Bresnan (1982), the Completeness requirement can be formally defined as follows:

(105) Completeness:

> An f-structure is *locally complete* if and only if it contains all the governable grammatical functions that its predicate governs. An f-structure is *complete* if and only if it and all its subsidiary f-structures are locally complete.

Chapter 8 provides further discussion of the place of the PRED feature in the theory of the syntax-semantics interface and its role in ensuring syntactic wellformedness.

4.6.2. Coherence

F-structures which do not obey the Coherence requirement include extra governable grammatical functions that are not contained in the argument list of their semantic form:

(106) **David yawned the sink.*

The f-structure for this sentence is ill-formed:

(107) Ill-formed f-structure:

$$\begin{bmatrix} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`David'} \end{bmatrix} \\ \text{OBJ} & \begin{bmatrix} \text{PRED} & \text{`SINK'} \\ \text{DEF} & + \end{bmatrix} \end{bmatrix}$$

The governable grammatical function OBJ is present in this f-structure, though it is not governed by the semantic form of *yawn*. Consequently, the f-structure is incoherent.

Of course, the Coherence requirement applies only to *governable* grammatical functions, not functions that are ungoverned, such as modifying adjuncts. The following f-structure is perfectly coherent. Besides the single governable function SUBJ, it contains a modifier ADJ, which is not a governable function:

(108) *David yawned yesterday.*

$$\begin{bmatrix} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`David'} \end{bmatrix} \\ \text{ADJ} & \left\{ \begin{bmatrix} \text{PRED} & \text{`YESTERDAY'} \end{bmatrix} \right\} \end{bmatrix}$$

An f-structure is coherent if all of its governable grammatical functions are governed by a predicate. The following f-structure is incoherent, since there is no PRED in the larger f-structure whose argument list contains OBJ:

(109) Ill-formed f-structure:

$$\left[\text{OBJ}\quad\left[\text{PRED}\quad\text{`David'}\right]\right]$$

It is usual but not necessary for the argument list of a predicate to mention single grammatical functions and not lists of functions or paths through the f-structure. In some treatments of subcategorized oblique phrases, however, the argument list of a predicate contains longer expressions, such as OBL_{ON} OBJ; see, for example, Levin (1982) and Falk (2001b):

(110) *David relied on Chris.*

$$\left[\begin{array}{ll} \text{PRED} & \text{`RELY}\langle\text{SUBJ},\text{OBL}_{\text{ON}}\ \text{OBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\text{PRED}\quad\text{`David'}\right] \\ \text{OBL}_{\text{ON}} & \left[\text{OBJ}\quad\left[\text{PRED}\quad\text{`Chris'}\right]\right] \end{array}\right]$$

This f-structure is coherent because the governable grammatical functions it contains are mentioned in the argument list of *rely*. That is, '$\text{RELY}\langle\text{SUBJ},\text{OBL}_{\text{ON}}\ \text{OBJ}\rangle$' governs the OBJ of the oblique function OBL_{ON}. We do not adopt this treatment of oblique phrases here, but merely display an example to illustrate this possibility; the representation we will use is shown in (89).

The Coherence requirement can be formally defined as follows (Kaplan and Bresnan 1982):

(111) Coherence:

An f-structure is *locally coherent* if and only if all the governable grammatical functions that it contains are governed by a local predicate. An f-structure is *coherent* if and only if it and all its subsidiary f-structures are locally coherent.

4.6.3. Consistency

The Consistency requirement, or Uniqueness Condition, reflects the functional (as opposed to relational) nature of the f-structure. An attribute of an f-structure may have only one value, not more (Kaplan and Bresnan 1982):

(112) Consistency:

In a given f-structure a particular attribute may have at most one value.

This requirement disallows f-structures satisfying incompatible constraints:

(113) **The boys yawns.*

Ill-formed f-structure:

$$\left[\begin{array}{ll} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`BOYS'} \\ \text{INDEX} & \left[\begin{array}{ll} \text{NUM} & \text{SG/PL} \end{array}\right] \end{array}\right] \end{array}\right]$$

The SUBJ noun phrase *the boys* is a plural (PL) phrase, but the verb *yawns* requires its subject to be singular (SG). These two requirements cannot be simultaneously met: the value of the attribute NUM must be either SG or PL, and it cannot have both values at the same time.

5. FUNCTIONAL FEATURES

The f-structure attribute PRED, whose value is a semantic form, is crucial in the statement of syntactic subcategorization requirements. The appearance and distribution of other f-structural features is constrained in terms of functional syntactic relations, and so their presence at f-structure is essential: agreement features such as PERS and NUM are specified for particular grammatical functions, such as SUBJ in subject-verb agreement; features specifying form, such as CASE and VTYPE (discussed in Section 5.5.1), are relevant at a functional syntactic level for specifying the required morphological form of an argument; and "sequence of tense" phenomena govern syntactic requirements on tense and aspect realization. Only features that can be argued to play a role in functional syntactic constraints are represented at f-structure; features encoding purely semantic, prosodic, or information-structural content are represented at other, nonsyntactic levels of representation, as we discuss in Part II of the book.

5.1. Simple and Complex Values

Features can have various kinds of values: the value of features like SUBJ and OBJ is an f-structure, the value of the PRED feature is a semantic form, and the value of a feature like DEF (encoding definiteness) is an atom such as +, with no internal structure. Some features have complex, nonatomic values whose structure is motivated by patterns involving feature resolution, feature indeterminacy, syntactic compositionality, or natural classes of feature values.

For example, the value of the feature PERS (person) is often represented as a simple atomic value such as 1, 2, or 3:

(114) Simple atomic values for the feature PERS: 1 (first person), 2 (second person), 3 (third person)

However, atomic values such as these do not underpin a predictive theory of *feature resolution* in coordination. For example, a theory of syntactic feature resolution should predict that coordinating a second person pronoun with a third person pronoun produces a coordinate phrase with a second person feature in every language (Corbett 2000), and that other resolution patterns are impossible:

(115) [*you*$_2$ *and he*$_3$]$_2$

Similarly, the use of atomic features does not allow for a formally explicit theory of *natural classes* of features and syncretism (Baerman et al. 2005). For example, Baerman et al. (2002) present the following paradigm for present tense verbs in Rongpo,[28] exemplifying with the verb 'go':

(116) Present tense of the verb 'go', Rongpo:

<table>
<tr><th></th><th>SG</th><th>PL</th></tr>
<tr><td>1</td><td>gyən̊</td><td rowspan="3">gyən̊i</td></tr>
<tr><td>2</td><td rowspan="2">gyən</td></tr>
<tr><td>3</td></tr>
</table>

The same verb form *gyən* is used with second and third person singular subjects. Representation of the value of the PERS feature as a simple atomic value such as 2 or 3 does not allow for the formal expression of properties (such as 'non-first-person') that the two values have in common. As Baerman et al. (2005, Chapter 3) point out, other languages display syncretisms involving first/third person and first/second person, and so the complex value of the PERS feature must allow reference to these commonalities as well. We discuss proposals for the complex representation of the value of the PERS feature in Section 5.7.2.

It is also often assumed that the NUM (number) feature has simple atomic values such as SG (singular), DU (dual), and PL (plural):

(117) Simple atomic values for the feature NUM: SG (singular), DU (dual), PL (plural)...

However, this representation does not support an explanatory theory of *constructed number*, where the value of the NUM feature is determined by a combination of constraints associated with different words in the sentence. Sadler (2011) discusses the data in (118) from Hopi, taken from Corbett (2000, page 169), in which pronouns distinguish singular number (SG) from nonsingular number (NONSG, more than one individual), while verbs distinguish plural number (PL, more than two individuals) from nonplural number (NONPL, one or two individuals). A subject is interpreted as having dual number if a nonsingular pronoun (reference to more than one individual) appears with nonplural verb agreement (reference to one or two individuals):

(118) a. *Pam wari*
that.SG run.NONPL

[28] Baerman et al. (2002) attribute the data in (116) to Zoller (1983).

'S/he ran.'

b. *Puma* *yùutu*
that.NONSG run.PL
'They ran.'

c. *Puma* *wari*
that.NONSG run.NONPL
'They (two) ran.'

Thus, dual number in Hopi is constructed by a combination of NONSG nominal number and NONPL verbal agreement. In Section 5.7.4, we discuss proposals for accounting for these patterns on the basis of a complex value for the NUM feature.

Finally, it is often assumed that the value of the feature CASE is a simple atomic value such as NOM, ACC, or DAT:

(119) Simple atomic values for the feature CASE: NOM (nominative), ACC (accusative), DAT (dative), ERG (ergative), ABS (absolutive), GEN (genitive), LOC (locative)...

Atomic values do not support a predictive theory of *case indeterminacy* (Zaenen and Karttunen 1984; Pullum and Zwicky 1986), illustrated in (120), in which a form can satisfy more than one case requirement at the same time. The German verb *findet* 'finds' requires an accusative object, and the verb *hilft* 'helps' requires a dative object. The noun phrase *Papageien* 'parrots' is indeterminately specified for case, and can appear with a verb requiring an accusative object (120a), a verb requiring a dative object (120b), or, crucially, as the object of both verbs at the same time (120c):

(120) a. *Er findet* *Papageien.*
he finds parrots
OBJ:ACC NOM/ACC/DAT/GEN
'He finds parrots.'

b. *Er hilft* *Papageien.*
he helps parrots
OBJ:DAT NOM/ACC/DAT/GEN
'He helps parrots.'

c. *Er findet* *und hilft* *Papageien.*
he finds and helps parrots
OBJ:ACC OBJ:DAT NOM/ACC/DAT/GEN
'He finds and helps parrots.'

Complex values for the CASE feature allow indeterminate forms to satisfy multiple conflicting case requirements simultaneously imposed by different predicates, as we discuss in Section 5.7.5.

A number of important theoretical and empirical issues arise in the determination of the proper representation of the values of features such as PERS, NUM, and CASE. We do not always take a firm stand on the proper analyses of the relevant cases, but it is vital to keep these issues in mind when determining the proper representation of the value of a feature. We hope that an explicit statement of these issues will help to guide future research on the structure and representation of complex feature values.

The first issue relates to *universality*. Is the representation and structure of the value of a feature determined on a language-by-language basis, or do all languages make use of the same representation? Can the same feature have a simple, atomic value in one language, and a complex value in another language? Can the same feature have different complex values in different languages?

The second is the issue of *the relation between syntax and meaning*. For semantically motivated features such as PERS and NUM, do we expect the structure of a complex f-structure feature value to partially or completely reflect details of the meaning of the elements bearing the features? If there is a systematic relation between the representation of a syntactic feature value at f-structure and the meaning of phrases bearing the feature, should this be attributed to historical factors, or do we require a synchronic theory of this relation?

The third is the issue of *markedness*.[29] Some feature values are traditionally classified as unmarked: for example, third person is usually classified as the unmarked value of the PERS feature. It is often proposed that there is an important relation between the markedness of a feature value and its representation: unmarked properties should be formally represented either by a negative value for a feature or by the absence of the feature, while marked values are represented by a positive value or by the presence of the feature. Should our representation of feature values conform to this generalization? We discuss technical issues that arise in the representation of a value of a feature by the absence of the feature in Section 5.2.

The fourth is the issue of *consistency of representation*. Do patterns of feature resolution, feature indeterminacy, syntactic compositionality, syncretism, and markedness converge on a single representation for the value of a feature? It may be, for example, that evidence from syncretism and natural classes of feature values motivates a particular representation of the complex value of a feature, while evidence from resolution motivates a different, incompatible representation. In such cases, which phenomenon takes precedence in determining how the value of a feature should be represented?

Besides these theoretical issues, a practical issue arises with regard to the f-structure representations that we will provide. Even though the representation of the CASE feature in (121a) does not support a theory of case indeterminacy, it is clearer, simpler, and easier to read than the representations in (121b) and (121c):

[29] For definition and discussion of markedness and the representation of feature values, see Jakobson (1932), Greenberg (1966a), Moravcsik (1988), Blevins (2000), and references cited in those works.

(121) a. $\begin{bmatrix}\textsc{case} & \textsc{acc}\end{bmatrix}$ (simple atomic representation)

b. $\begin{bmatrix}\textsc{case} & \{\textsc{acc}\}\end{bmatrix}$ (set-based representation)

c. $\begin{bmatrix}\textsc{case} & \begin{bmatrix}\textsc{nom} & - \\ \textsc{acc} & + \\ \textsc{dat} & - \\ & \vdots\end{bmatrix}\end{bmatrix}$ (feature structure representation)

Often, if we are not concerned with issues of feature indeterminacy, feature resolution, constructed values for features, or representing commonalities among feature values, our discussion will not depend on a particular representation of the value of the CASE feature or other features with complex values. In fact, the f-structures which we display will be easier to read if we adopt a simple representation such as the one in (121a) when possible. In this book, therefore, we follow the convention that if the details of the representation of a complex feature value are not important to the discussion, we represent it as a simple atomic value. In such cases, the simple value can be thought of as an abbreviation for the corresponding complex value.

5.2. The Absence of a Feature as a Feature Value

In some approaches, the absence of a feature is taken to represent one of the values of the feature. Features treated in this way are sometimes called *privative features*, though this term is often reserved for the particular case in which the feature has two values, represented as the presence or absence of the feature. In such cases, the absence of a feature is often thought of as representing the 'unmarked' value for the feature, with the 'marked' value represented as the presence of the feature.

For example, Falk (2001b, page 82) proposes the following features to represent the different forms of the English verb:

(122) present tense: $\begin{bmatrix}\textsc{tense} & \textsc{pres}\end{bmatrix}$

past tense: $\begin{bmatrix}\textsc{tense} & \textsc{past}\end{bmatrix}$

-*ing* form: $\begin{bmatrix}\textsc{part} & \textsc{pres}\end{bmatrix}$

-*ed*/-*en* form: $\begin{bmatrix}\textsc{part} & \textsc{past}\end{bmatrix}$

infinitive: nothing

On Falk's view, tensed forms are associated with a TENSE feature, participial forms are associated with a PART feature, and the infinitive is identified by the absence of both of these features.

One issue that arises for such approaches is the treatment of feature underspecification. In many approaches, a word form which can have several values for a feature is treated by leaving the value for the feature underspecified or unspecified. For example, the verb form *put* is the present tense form, the past tense form, or the infinitive form of the verb:

(123) a. *David and Chris put their dishes in the dishwasher every day.* [present tense]

b. *David and Chris put their dishes in the dishwasher yesterday.* [past tense]

c. *David and Chris don't want to put their dishes in the dishwasher today.* [infinitive]

Given Falk's system of feature specifications, we cannot analyze *put* by leaving the value of the TENSE feature unspecified, since the lack of a TENSE feature (along with the lack of a PART feature) marks the form as infinitival, and is not compatible with the representation of a tensed form. This means that if the absence of a feature is treated as signaling one of the values of the feature, some other approach to underspecification must be taken. See Payne and Börjars (2015) for further discussion of this issue, and Kaplan (2017) for an overview discussion of underspecification and feature indeterminacy.

We now turn to an examination of the particular f-structure features and their values that we assume in this book.

5.3. FORM Features

Some predicates require one or more of their arguments to contain words of a particular form. For example, English weather verbs such as *rain* and *snow* require a pleonastic or semantically empty subject which must have the form *it*:

(124) *It/*There/*∅ rained.*

It is, then, necessary to encode information about the form of words at f-structure, in order to allow such requirements to be stated. Word form is encoded by means of features such as FORM; the f-structure for *It rained* is:

(125) $\begin{bmatrix} \text{PRED} & \text{`RAIN}\langle\rangle\text{SUBJ'} \\ \text{SUBJ} & \begin{bmatrix} \text{FORM} & \text{IT} \end{bmatrix} \end{bmatrix}$

Notice that the SUBJ argument of *rain* appears outside the angled brackets in the semantic form, since it is syntactically required but does not make a semantic contribution (Section 4.6.1). The f-structure of the subject contains the attribute FORM with value IT, satisfying the special requirements of the verb *rained*.

This means that the pronoun *it* makes one of two different f-structure contributions on each occasion of its use: one of them, shown in (125), has a FORM attribute with value IT, while the other is a standard referential pronoun containing a PRED attribute with value 'PRO', as in a sentence like *David saw it*. It is generally assumed that the only words which have an f-structure with a FORM feature are those whose presence is syntactically required by some predicate in the language but which do not make a semantic contribution. For example, there is no English verb that requires the presence of an argument with the form *hippopotamus*, and so there is no f-structure for the word *hippopotamus* which contains a FORM feature and no PRED feature.

Some verbs place constraints on the form of the complementizer of their complement clause; for example, Quirk et al. (1972, 15.6) claim that the verb *justify* allows the complementizer *whether*, but not the complementizer *if*, in its COMP argument.

(126) *You have to justify whether/*if your journey is really necessary.*

A complementizer like *that* or *whether* contributes its features to the same f-structure as its complement clause, as we will see in Chapter 4. When more than one word contributes information to the same f-structure, it is not possible for both words to contribute values for the same FORM feature, since this causes a clash. This means that complements must contribute a special attribute COMPFORM whose value is the form of the complementizer. Thus, a sentence like *Chris knows whether David left* has the f-structure given in (127), in which the subordinate clause COMP has a COMPFORM feature with value WHETHER:

(127) *Chris knows whether David left.*

$$\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{know}\langle\textsc{subj},\textsc{comp}\rangle\text{'} \\ \textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{Chris}\text{'}\end{array}\right] \\ \textsc{comp} & \left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{leave}\langle\textsc{subj}\rangle\text{'} \\ \textsc{compform} & \textsc{whether} \\ \textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{David}\text{'}\end{array}\right] \end{array}\right] \end{array}\right]$$

It is the value of the COMPFORM feature that is constrained by the verb *justify*, which disallows the value IF for the COMPFORM feature in its COMP. We return to a discussion of this example in Chapter 5, Section 2.5.

In their comparative grammars of English, French, and German, Butt et al. (1999) propose a number of additional specialized FORM features, including PRON-FORM for pronouns, SPEC-FORM for nominal specifiers like *the*, CONJ-FORM and PRECONJ-FORM for conjunctions like *and* and preconjunctions like *either* or *both*, PRT-FORM for particles (including German verbal particles as well as English particles like *up*), and COMP-FORM (which we call COMPFORM). In the computational setting of Butt et al.'s work, the linguistic analysis of a sentence is input to a computer application that performs further processing for some practical purpose. In such a setting, features such as these are often included in the analysis in case they are useful for such applications, rather than for purely syntactic reasons. In the analyses we present, we introduce only f-structure features which we can show to be clearly motivated by syntactic patterns and which take part in syntactic selection requirements. It may be that further research will reveal the need for additional FORM features at f-structure such as those that Butt et al. (1999) propose.

In Chapter 11, Section 4.1, we will introduce an FM string feature whose value is the form of the unit of the string under analysis. We will see that the FM feature bears a close relation to the f-structure FORM feature, but is relevant for relations in the string rather than f-structural relations and constraints.

5.4. PFORM and PCASE

Prepositions and particles contribute information about their form, by means of the PFORM feature. Additionally, prepositions may be specified with information about the grammatical function of the argument which they mark; this information is recorded as the value of the PCASE feature.

The PCASE feature reflects the fact that the grammatical role of an oblique prepositional phrase is often determined by the preposition. Kaplan and Bresnan (1982) propose the (now non-standard) f-structure in (128) for the sentence *A girl handed a toy to the baby*:

(128) Non-standard f-structure for *A girl handed a toy to the baby* according to Kaplan and Bresnan (1982, (45)):

$$\left[\begin{array}{ll} \text{SUBJ} & \left[\begin{array}{ll}\text{SPEC} & \text{A}\\ \text{PRED} & \text{`GIRL'}\end{array}\right] \\ \text{TENSE} & \text{PST} \\ \text{PRED} & \text{`HAND}\langle\text{SUBJ, OBJ, TO OBJ}\rangle\text{'} \\ \text{OBJ} & \left[\begin{array}{ll}\text{SPEC} & \text{A}\\ \text{PRED} & \text{`TOY'}\end{array}\right] \\ \text{TO} & \left[\begin{array}{ll}\text{PCASE} & \text{TO}\\ \text{OBJ} & \left[\begin{array}{ll}\text{SPEC} & \text{THE}\\ \text{PRED} & \text{`BABY'}\end{array}\right]\end{array}\right]\end{array}\right]$$

According to this early analysis, the value of the PCASE attribute is TO, which is also the grammatical function of the phrase *to the baby* (see Butt et al. 1999 for a different but related treatment). In later work, two different attributes have generally been assumed: the form of the preposition is instead recorded as the value of the PFORM feature, as we describe below, while the value of the PCASE attribute is specified as the particular oblique grammatical function contributed by the prepositional phrase. For example, in (129), the value of the PFORM attribute is TO, and the value of the PCASE attribute is the grammatical function OBL_{GOAL}, which is also the grammatical function of the prepositional phrase *to the baby*:

(129) F-structure for *A girl handed a toy to the baby*, standard treatment of PCASE feature:

$$\left[\begin{array}{ll} \textsc{subj} & \left[\textsc{pred}\ \ \text{`}\textsc{girl}\text{'}\right] \\ \textsc{pred} & \text{`}\textsc{hand}\langle\textsc{subj},\ \textsc{obj},\ \textsc{obl}_{\textsc{goal}}\rangle\text{'} \\ \textsc{obj} & \left[\textsc{pred}\ \ \text{`}\textsc{toy}\text{'}\right] \\ \textsc{obl}_{\textsc{goal}} & \left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{baby}\text{'} \\ \textsc{pform} & \textsc{to} \\ \textsc{pcase} & \textsc{obl}_{\textsc{goal}} \end{array}\right] \end{array}\right]$$

In Chapter 6, Section 2, we describe the constraints which allow the value of the PCASE attribute to specify the grammatical function borne by the oblique phrase.[30]

F-structural specification of the form of particles or prepositions is necessary because predicates can place idiosyncratic requirements on the form of their prepositional complements or particles (Section 1.9.2):

(130) a. *David relied on/*to/*about Chris.*

b. *David used the sugar up/*down/*through.*

The PFORM feature records the value of the form of the particle or preposition so that it can be constrained and checked by the predicate:[31]

(131) a. *David relied on Chris.*

$$\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{rely}\langle\textsc{subj},\ \textsc{obl}_{\textsc{on}}\rangle\text{'} \\ \textsc{subj} & \left[\textsc{pred}\ \ \text{`David'}\right] \\ \textsc{obl}_{\textsc{on}} & \left[\begin{array}{ll} \textsc{pred} & \text{`Chris'} \\ \textsc{pform} & \textsc{on} \end{array}\right] \end{array}\right]$$

b. *David used the sugar up.*

$$\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{use.up}\langle\textsc{subj},\ \textsc{obj}\rangle\text{'} \\ \textsc{subj} & \left[\textsc{pred}\ \ \text{`David'}\right] \\ \textsc{obj} & \left[\textsc{pred}\ \ \text{`}\textsc{sugar}\text{'}\right] \\ \textsc{pform} & \textsc{up} \end{array}\right]$$

5.5. Verbal and Clausal Features

Much previous LFG work has made use of verbal and clausal features such as VTYPE and TENSE, but there has not always been agreement on the appropriate values for these features. Influential proposals have been made by Butt et al.

[30] As we discuss in Chapter 6, Sections 1.3 and 2, the PCASE analysis is closely related to the constructive case theory of Nordlinger (1998, 2000).

[31] See Toivonen (2003) for an in-depth discussion of particles in Germanic languages, and an alternative proposal for the f-structure of English particle verbs.

(1999), Falk (2001b, Section 3.5, discussed in Section 5.2 above), and Payne and Börjars (2015). MOOD, ASPECT, and VOICE are also important features in verbal and clausal analysis.

5.5.1. VTYPE AND TENSE

We adopt the proposal of Payne and Börjars (2015) for the VTYPE and TENSE features and their values. On their proposal, all verb forms have a VTYPE feature, and tensed forms also have a TENSE feature:[32]

(132) Finite present non-third singular (*help*): $\begin{bmatrix} \text{VTYPE} & \text{FIN} \\ \text{TENSE} & \text{PRS} \end{bmatrix}$

Finite present third singular (*helps*): $\begin{bmatrix} \text{VTYPE} & \text{FIN} \\ \text{TENSE} & \text{PRS} \end{bmatrix}$

Finite past (*helped*): $\begin{bmatrix} \text{VTYPE} & \text{FIN} \\ \text{TENSE} & \text{PST} \end{bmatrix}$

Present participle (*helping*): $\begin{bmatrix} \text{VTYPE} & \text{PRS.PTCP} \end{bmatrix}$

Past participle (*helped*): $\begin{bmatrix} \text{VTYPE} & \text{PST.PTCP} \end{bmatrix}$

Bare infinitive (*help*): $\begin{bmatrix} \text{VTYPE} & \text{INF} \end{bmatrix}$

The VTYPE feature has the values listed in (133) in English; additional values may be required for other languages, depending on the richness of the verbal paradigm.

(133) Values for the VTYPE feature: FIN (finite), PRS.PTCP (present participle), PST.PTCP (past participle), INF (bare infinitive)

For English, the TENSE feature has at least the values past (PST) and present (PRS). There is some controversy over the status of English *will* as a future tense marker (Huddleston 1995); we do not take a position on this issue here, though we note that FUT is a possible value for the TENSE feature in many languages.

(134) Values for the TENSE feature: PST (past), PRS (present), FUT (future)

Some languages make additional distinctions by subdividing past or future tense, distinguishing, for example, recent from remote past tense or near from remote future tense (Comrie 1985); additional values of the f-structure TENSE feature may be needed in the analysis of these languages, depending on the relevance of these semantic distinctions for syntactic analysis.[33]

[32] Payne and Börjars use the attribute VFORM rather than VTYPE for this feature. For consistency with the Leipzig glossing rules (Bickel et al. 2015), we provide the value PRS.PTCP for the present participial form of a verb, rather than Payne and Börjars's GER-PART.

[33] Here and in general, it is worth keeping in mind that the f-structure is a purely syntactic representation, and need not encode fine-grained semantic distinctions. The distinction between near and

The TENSE feature has also been argued to have a complex, nonatomic value. Nordlinger and Bresnan (1996) present an insightful analysis of tense marking in Wambaya that decomposes the value of the TENSE feature into three primitive binary features: ±PAST, ±FUTURE, and ±UNCERTAIN. In this book we will supply an atomic value such as PST or PRS for the feature TENSE: as discussed in Section 5.1, we may think of this as an abbreviation for a complex value in languages like Wambaya, where a decomposition of the value of the TENSE feature is motivated.

5.5.2. MOOD AND ASPECT

Besides the TENSE feature, ASPECT and MOOD constitute the other two dimensions of tense-aspect-mood systems (often abbreviated as TAM). We adopt Butt et al.'s (1999) treatment of the MOOD feature, and a variant of their analysis for the ASPECT feature.

Butt et al. (1999) propose the values IND (indicative), SBJV (subjunctive), and IMP (imperative) for the feature MOOD in English, French, and German; to these, we add the value INTERR (interrogative):

(135) Values for the MOOD feature: IND (indicative), SBJV (subjunctive), IMP (imperative), INTERR (interrogative)

For other languages, additional values may be required: for example, Ancient Greek has an optative (OPT) mood.

The treatment of ASPECT is more complex. Butt et al.'s analysis of English, French, and German makes use of an aspect feature which they abbreviate as PERF. Butt et al. (1999) do not distinguish between perfect and perfective aspect in their representation of the ASPECT feature; we follow standard practice in using PRF for perfect aspect, and PFV for perfective aspect. We also follow Butt et al. in using a single feature, which we represent as PRF, in the analysis of aspectual distinctions in English, French, and German.

According to Butt et al.'s analysis of English, the feature PRF appears with value + for sentences with the perfect auxiliary, and does not appear in sentences without the perfect auxiliary:

(136) a. *David has eaten a banana*: $\begin{bmatrix} \text{ASPECT} & \begin{bmatrix} \text{PRF} & + \end{bmatrix} \end{bmatrix}$

b. *David ate a banana*: no ASPECT feature

Butt et al. also propose a feature PROG (progressive), since in English, a sentence can have both perfect and progressive aspect:

(137) *David has been eating bananas*: $\begin{bmatrix} \text{ASPECT} & \begin{bmatrix} \text{PRF} & + \\ \text{PROG} & + \end{bmatrix} \end{bmatrix}$

---

remote past may not be syntactically significant in any language, even when it is important semantically; whether or not the full range of semantically relevant distinctions is encoded in the f-structure is one aspect of the general issue of the relation between syntax and meaning, discussed in Section 5.1.

A representation like this works well for languages like English, in which two separate dimensions of the ASPECT feature must be represented in the same f-structure. We provide the representation in (138) for such languages, similar to the representation proposed by Butt et al. (1999):

(138) Complex values for the ASPECT feature:

Perfect: $$\left[\begin{array}{ll}\text{ASPECT} & \left[\begin{array}{ll}\text{PRF} & +\end{array}\right]\end{array}\right]$$

Progressive: $$\left[\begin{array}{ll}\text{ASPECT} & \left[\begin{array}{ll}\text{PROG} & +\end{array}\right]\end{array}\right]$$

Perfect progressive: $$\left[\begin{array}{ll}\text{ASPECT} & \left[\begin{array}{ll}\text{PRF} & + \\ \text{PROG} & +\end{array}\right]\end{array}\right]$$

We occasionally use atomic symbols as abbreviations for the complex structure in (138): for example, we can use the abbreviation PRF.PROG as an abbreviation for the complex value given in (138) for perfect progressive aspect.

For languages whose aspectual syntax does not require consideration of more than one dimension of aspect for any sentence, a simpler representation suffices, using the attribute ASPECT with an atomic value:

(139) Atomic values for the ASPECT feature: PRF (perfect), IPRF (imperfect), PFV (perfective), IPFV (imperfective), PROG (progressive)

For an alternative proposal for the f-structural representation of aspect, including a discussion of lexical aspect or *aktionsart*, see Glasbey (2001).

It is worth noting that TENSE, ASPECT, and MOOD are not exclusively clausal categories. Nordlinger and Sadler (2004a,b) discuss TAM marking on nominals in a number of languages, and Arka (2013) discusses nominal aspect marking in Marori. Nordlinger and Sadler show that in some cases, TAM marking appearing on nominals marks the TAM of the clause in which the nominal phrase appears; in other cases, nominal TAM marking is relevant to the timespan of the referent of the noun phrase, and may differ from the TAM of the clause. Arka shows that the same is true of nominal aspect in Marori. As motivation for representing nominal TAM in the f-structure, Nordlinger and Sadler show that TENSE is involved in syntactic agreement relations within the noun phrase in Somali: adjectives agree in TENSE and GEND with the head noun, and so TENSE must be represented in the f-structure of nouns in Somali and other languages with TAM agreement within the noun phrase. Nordlinger and Sadler (2004b) and Arka (2013) present LFG analyses of nominal tense and aspect which ensure that the TAM features are available for syntactic agreement relations where necessary, and that the features appear in the correct f-structure in each instance.

5.5.3. VOICE

Many voice systems encode a two-way distinction between active and passive voice; to represent this distinction, Sadler and Spencer (2001) propose a feature

VOICE with values ACTIVE (active) and PASS (passive). Often, active voice is treated as the unmarked, default value for the VOICE feature: if we adopt this view in Sadler and Spencer's setting, active voice can be represented by the absence of the VOICE feature, and passive voice can be represented by the presence of the VOICE feature with the value PASS. Additional values for the VOICE feature are necessary in the analysis of languages with antipassive voice (ANTIP) and middle voice (MID) (Fox and Hopper 1993).

As we discuss in Chapter 9, voice alternations are often viewed in terms of 'promotion' and 'demotion' of arguments, with the active voice taken as basic, and the passive voice involving 'demotion' of the subject to oblique status, and 'promotion' of a nonsubject argument to subject status. Many languages have voice systems which do not work in this way: in so-called 'symmetric voice systems' (Foley 1998), voice alternations involve singling out one argument as the SUBJ, but without demoting the other core arguments or altering their core status. Such systems often have several voices, each named after the role of the argument that is singled out as the SUBJ. For example, Kroeger (1993) discusses five voices in Tagalog: actor voice (sometimes called "active voice": AV), objective voice (OV), dative/locative voice (DV), instrumental voice (IV), and benefactive voice (BV). Interestingly, Arka (2003) shows that Balinese has a three-way voice alternation, with demotional and symmetric voice alternations coexisting in the same language: Balinese distinguishes agentive voice (similar to actor voice in Tagalog, and also represented as the value AV), a non-demotional objective voice (OV) in which the agent remains a core argument, and a demotional passive voice (PASS) in which the agent is demoted to oblique status. Kroeger (1993), Arka (2003), and Falk (2006) provide an in-depth discussion of these 'symmetric voice' languages, their clausal syntactic organization, and their analysis within the theory of argument mapping, the relation between grammatical functions and semantic roles; we discuss argument mapping in Chapter 9.

In languages with direct and inverse voice, the status of the arguments of a verbal predicate and their position on an animacy/saliency hierarchy determines the voice of a clause: for example, a first person agent acting on a third person patient must be expressed with direct voice (DIR), but a third person agent acting on a first person patient must be expressed in inverse voice (INV) (see Chapter 5, Section 2.10 for a discussion of related patterns in Lummi). Arnold (1994) provides an analysis of argument mapping and inverse voice in Mapudungan.

Our inventory of values for the VOICE feature must, then, encompass values that are relevant in the analysis of demotional voice alternations such as the ACTIVE/PASS alternation as well as voice alternations in symmetric voice languages and languages with direct and inverse voice. Additional values may be needed in the analysis of symmetrical voice languages with voice distinctions other than those attested in Tagalog and Balinese.

(140) Values for the VOICE feature: ACTIVE (active), PASS (passive), ANTIP (antipassive), MID (middle), AV (actor/agentive voice), OV (objective voice),

DV (dative voice), BV (benefactive voice), IV (instrumental voice), DIR (direct voice), INV (inverse voice)

5.6. Negation

The presence of negation affects syntactic patterns such as case assignment and negative concord (see Przepiórkowski and Patejuk 2015 for Polish), and so negation must be represented explicitly at f-structure. Clausal negation is represented by a feature NEG with value + by King (1995), Butt et al. (1999), and Falk (2001b), among others:

(141) F-structure for *David didn't yawn* with NEG feature:

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`David'} \end{bmatrix} \\ \textsc{neg} & + \end{bmatrix}$$

A related feature, NEG-FORM, is proposed by Butt et al. (1999, pages 142–143) in the analysis of bipartite clausal negation forms such as French, with the initial component contributing a NEG feature, and the postnegation component contributing the value of NEG-FORM.

(142) F-structure for French bipartite negation *ne...pas* according to Butt et al. (1999):

David	*n'*	*a*	*pas*	*mangé*	*de*	*soupe.*
	NEG	have	POSTNEG	eaten	of	soup

'David did not eat any soup.'

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{eat}\langle\textsc{subj}, \textsc{obj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`David'} \end{bmatrix} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{`}\textsc{soup}\text{'} \end{bmatrix} \\ \textsc{neg} & + \\ \textsc{neg-form} & \textsc{pas} \end{bmatrix}$$

Butt et al. (1999, page 143) propose that the NEG feature is also used in the treatment of constituent negation, where only a subconstituent is negated and not the entire clause.

(143) F-structure for *David found the ball not in the box [but on the floor. . .]* according to Butt et al. (1999):

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{find}\langle\textsc{subj}, \textsc{obj}, \textsc{obl}_{\textsc{loc}}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`David'} \end{bmatrix} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{`}\textsc{ball}\text{'} \end{bmatrix} \\ \textsc{obl}_{\textsc{loc}} & \begin{bmatrix} \textsc{pred} & \text{`}\textsc{in}\langle\textsc{obj}\rangle\text{'} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{`}\textsc{box}\text{'} \end{bmatrix} \\ \textsc{neg} & + \end{bmatrix} \end{bmatrix}$$

However, a single NEG feature may not be adequate in the analysis of multiple negation examples such as (144), from Przepiórkowski and Patejuk (2015):

(144) *John doesn't not like Mary.*

An undesirable analysis of example (144) would be for each occurrence of *not* in (144) simply to require the value + for the NEG feature in the clausal f-structure, since this would render the resulting f-structure indistinguishable from the f-structure for *John doesn't like Mary*, with only one negation:

(145) F-structure for *John doesn't like Mary* with NEG feature:

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{like}\langle\textsc{subj}, \textsc{obj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`John'} \end{bmatrix} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{`Mary'} \end{bmatrix} \\ \textsc{neg} & + \end{bmatrix}$$

To ensure the proper treatment of examples with multiple negation, the ParGram Consortium (2017) proposes to treat at least some instances of clausal negation adverbially, with an f-structure representing clausal negation in the ADJ set:

(146) F-structure for *John doesn't like Mary* with negation as an adjunct:

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{like}\langle\textsc{subj}, \textsc{obj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`John'} \end{bmatrix} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{`Mary'} \end{bmatrix} \\ \textsc{adj} & \left\{ \begin{bmatrix} \textsc{pred} & \text{`}\textsc{not}\text{'} \end{bmatrix} \right\} \end{bmatrix}$$

This representation allows multiple instances of negation to be represented separately, each as a member of the ADJ set:

(147) F-structure for *John doesn't not like Mary* with negation as an adjunct:

$$\begin{bmatrix} \text{PRED} & \text{`LIKE}\langle\text{SUBJ, OBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`John'} \end{bmatrix} \\ \text{OBJ} & \begin{bmatrix} \text{PRED} & \text{`Mary'} \end{bmatrix} \\ \text{ADJ} & \left\{ \begin{array}{l} \begin{bmatrix} \text{PRED} & \text{`NOT'} \end{bmatrix} \\ \begin{bmatrix} \text{PRED} & \text{`NOT'} \end{bmatrix} \end{array} \right\} \end{bmatrix}$$

In his analysis of negation in Hungarian, Laczkó (2015) introduces an additional polarity feature POL, and proposes that different morphosyntactic realizations of negation are represented differently: affixal negation (which cannot be iterated) is represented by the [NEG +] feature, while clausal or constituent negation (encoded by the negative particle in Hungarian) is represented as a member of the ADJ set, as in (147), and additionally by a [POL NEG] feature to mark the scope of negation. In related work, Przepiórkowski and Patejuk (2015) explore the possibility of using only the NEG and POL features, eschewing the adverbial representation in (147). They argue that the two features NEG and POL are adequate to handle doubly negated examples such as (144) as well as the distinction between clausal negation (which they call 'eventuality negation') and constituent negation. For more on the morphological and syntactic representation of negation, see Laczkó (2014c, 2015), Przepiórkowski and Patejuk (2015), Bond (2016), and the ParGram Consortium (2017).

5.7. Nominal Features

Nominal features are different from clausal features in that they behave specially in coordination; an important component of the analysis of nominal features is the distinction between distributive and nondistributive features, introduced in Section 4.5. Another dimension of difference is the classification of nominal features governing agreement relations into INDEX features and CONCORD features. In this section, we discuss nominal features and their values, including DEF, SPEC, DEIXIS, PRONTYPE, PERS, GEND, NUM, and CASE.

5.7.1. Agreement Features: INDEX and CONCORD

Nominal features relevant for syntactic agreement and government relations include person (PERS), number (NUM), gender (GEND), and case (CASE). Wechsler and Zlatić (2003) argue convincingly that these features make up two different feature bundles, INDEX and CONCORD (see also Pollard and Sag 1994, Kathol 1999, King and Dalrymple 2004, Wechsler 2011, Hristov 2012, Belyaev et al. 2015, and

Haug and Nikitina 2016).[34,35] INDEX features group together PERS, NUM, and GEND features; although INDEX features are syntactic features and appear in f-structure, they are closely related to semantic features and the meaning of the phrase bearing the features. Wechsler (2011) proposes that INDEX features derive historically from incorporated pronouns, accounting for the presence of the PERS feature in the INDEX bundle. In contrast, CONCORD features group together CASE, NUM, and GEND features. Like INDEX, CONCORD features are f-structure features, but CONCORD is more closely related to morphological declension class; according to Wechsler (2011), CONCORD features derive historically from nonpronominal sources, often from incorporated nominal classifiers, accounting for the presence of CASE but not PERS in the CONCORD bundle.

(148)
$$\begin{bmatrix} \text{CONCORD} & \begin{bmatrix} \text{NUM} & \ldots \\ \text{GEND} & \ldots \\ \text{CASE} & \ldots \end{bmatrix} \\ \text{INDEX} & \begin{bmatrix} \text{PERS} & \ldots \\ \text{NUM} & \ldots \\ \text{GEND} & \ldots \end{bmatrix} \end{bmatrix}$$

As shown in (148), both the INDEX feature bundle and the CONCORD feature bundle contain NUM and GEND features. Since INDEX and CONCORD features are specified separately, the values of these features can differ: for example, a form can have singular CONCORD but plural INDEX, or vice versa. Wechsler and Zlatić (2003, page 51) provide the Bosnian/Croatian/Serbian[36] example in (149) to illustrate this possibility:

(149) *Ta dobra deca dolaze.*
that.F.SG good.F.SG children come.3PL
'Those good children are coming.'

The noun *deca* 'children' controls feminine singular agreement on the determiner and adjective, but third person plural agreement on the verb. Wechsler and Zlatić propose that *deca* is unusual in having feminine singular CONCORD features but neuter plural INDEX features:

[34] Bresnan et al. (2016, Chapter 8) also group PERS, NUM, and GEND features together as components of the value of the INDEX feature, as we do here. They provide a different treatment of INDEX and agreement features in their discussion of anaphoric binding in their Chapter 10, where they use the cover term *agr* for PERS, NUM, and GEND features, and provide a variable such as *i* or *j* for the value of the attribute INDEX.

[35] Alsina and Arsenijević (2012a,b) argue against the INDEX/CONCORD distinction and in favor of a single type of syntactic agreement feature; Wechsler and Zlatić (2012) and Hristov (2013a) provide counterarguments to Alsina and Arsenijević's position.

[36] Due to the complexity of the political and linguistic divisions in the former Yugoslavia we use the name Bosnian/Croatian/Serbian to refer to the primary languages of Bosnia and Herzegovina, Croatia, Montenegro and Serbia, without prejudice as to how many distinct languages or varieties this encompasses and without implying primacy of one variety or language over others.

(150) INDEX and CONCORD features for *deca*, Wechsler and Zlatić (2003):

$$\begin{bmatrix} \text{CONCORD} & \begin{bmatrix} \text{NUM} & \boxed{\text{SG}} \\ \text{GEND} & \text{F} \end{bmatrix} \\ \text{INDEX} & \begin{bmatrix} \text{PERS} & 3 \\ \text{NUM} & \boxed{\text{PL}} \\ \text{GEND} & \text{N} \end{bmatrix} \end{bmatrix}$$

Subject-verb agreement is often determined by INDEX features, as in example (149): the verb *dolaze* 'come.3PL' shows third person plural INDEX agreement with its subject. In contrast, NP-internal agreement, including adjective-noun agreement, is often determined by CONCORD features: here, the demonstrative determiner *ta* and the adjective *dobra* 'good.F.SG' show feminine singular CONCORD agreement with *deca* 'children'.

INDEX and CONCORD features have been claimed to differ in their status as distributive or nondistributive features in coordination. Recall from Section 4.5 that nondistributive features are associated with a coordinate structure as a whole; in contrast, distributive features are associated with each conjunct of a coordinate phrase, but not with the coordinate structure as a whole. King and Dalrymple (2004) argue that INDEX is a nondistributive feature, meaning that a coordinate structure can have its own INDEX features that may be different from the INDEX features of the conjuncts, while CONCORD is a distributive feature, and not a feature of a coordinate structure.

(151) INDEX as a nondistributive feature (King and Dalrymple 2004):

$$\begin{bmatrix} \text{INDEX} & [\ (\text{INDEX features of coordinate structure})\ ] \\ \multicolumn{2}{c}{\left\{ \begin{matrix} \begin{bmatrix} \text{INDEX} & [\ (\text{INDEX features of conjunct})\ ] \\ \text{CONCORD} & [\ (\text{CONCORD features of conjunct})\ ] \end{bmatrix} \\ \vdots \end{matrix} \right\}} \end{bmatrix}$$

The classification of INDEX as a nondistributive feature and CONCORD as a distributive feature is adopted by Dalrymple and Nikolaeva (2006), Vincent and Börjars (2007), Sadler and Nordlinger (2010), Hristov (2012), and many others. The view that CONCORD is always a distributive feature is challenged by Belyaev et al. (2015), who propose that CONCORD is distributive in some languages but nondistributive in others.

The status of INDEX as a nondistributive feature is important in the theory of syntactic feature resolution: the person (PERS) and gender (GEND) INDEX features of a coordinate phrase are determined in a systematic way by the PERS and GEND INDEX features of the conjuncts. The NUM feature is also a part of the INDEX feature complex, but it does not resolve in the same way as PERS or GEND. In our discussion of the PERS, NUM, and GEND features, we will examine different proposals for the complex values of these features and the role that they play in the f-structures of coordinated phrases and the theory of feature resolution. We postpone a full discussion of feature resolution and the features of coordinate noun phrases to Chapter 16.

5.7.2. Person

The PERS feature is often represented with a simple atomic value:[37]

(152) Simple atomic values for the feature PERS: 1 (first person), 2 (second person), 3 (third person)

There are two sorts of motivations for a more complex representation of the value of the PERS feature. First, as noted in Section 5.1, the PERS feature resolves in predictable ways in coordination: for English and many other languages, the resolution rules are as in (153). In a formal theory of syntactic feature resolution, complex values allow resolution to be modeled in a way that accounts for these patterns.

(153) Resolution of the PERS feature:

first & second	= first
first & third	= first
second & third	= second
third & third	= third

Secondly, as noted in Section 5.1, values of the PERS feature pattern together in agreement relations, and a complex representation allows for the definition of natural classes and commonalities in values of the PERS feature. We discuss analyses focusing on each of these phenomena in turn.

Dalrymple and Kaplan (2000) propose a theory of feature resolution which defines the value of the PERS feature as a *closed set*[38] containing the atoms S (mnemonic for speaker) and H (mnemonic for HEARER):

(154) Values for the PERS feature according to Dalrymple and Kaplan (2000):

$\{\textsc{s}, \textsc{h}\}$:	first person
$\{\textsc{h}\}$:	second person
$\{\}$:	third person

Dalrymple and Kaplan further propose that feature resolution can be modeled as set union:[39] the PERS value of a coordinate structure is determined by taking the

[37] Wechsler (2004) proposes additional atomic values for languages like French, which have a distinction in the first person between a singular pronoun (*je*) and a plural or 'authorial' singular pronoun (*nous*), and in the second person between an informal singular pronoun (*tu*) and a plural or formal singular pronoun (*vous*). According to Wechsler's analysis, values for the PERS feature in French are 1S (first person singular), 1A (first person associative or "authorial" first person), 2S (second person singular informal), and 2A (second person associative or formal); third person is represented by the absence of a first or second person feature.

[38] We define and discuss closed set descriptions in Chapter 6, Section 3.4.

[39] See Chapter 6, Section 3 for definitions of set relations such as set union and intersection.

set union of the PERS values of the conjuncts. The table in (155) represents exactly the same pattern of person agreement as the table in (153):

(155) Resolution of the PERS feature via set union (Dalrymple and Kaplan 2000):

{S, H} (first) ∪ {H} (second)	=	{S, H} (first)
{S, H} (first) ∪ {} (third)	=	{S, H} (first)
{H} (second) ∪ {} (third)	=	{H} (second)
{} (third) ∪ {} (third)	=	{} (third)

Other languages have a richer system of personal pronouns. For example, Fula and many other languages exhibit a distinction between *inclusive* and *exclusive* first person pronouns: the referent of an inclusive first person pronoun includes the hearer, while the referent of an exclusive first person pronoun excludes the hearer. For such languages, Dalrymple and Kaplan propose the following refinement to the feature values in (154):

(156) Values for the PERS feature in languages with a first person inclusive/exclusive distinction according to Dalrymple and Kaplan (2000):

{S, H}:	first person inclusive
{S}:	first person exclusive
{H}:	second person
{}:	third person

In their analysis of the PERS feature, Vincent and Börjars (2007) propose that the PERS feature has the inventory of feature values in (156) in all languages, distinguishing inclusive from exclusive pronouns in the first person, whether or not there is a morphological inclusive/exclusive distinction in the pronominal system.

In Section 5.1, we discussed theoretical issues that bear on the determination of the value of features like PERS. The issue of *universality* is whether all languages share the same representation and structure for the values of a feature like PERS. For Vincent and Börjars, universality is a high priority: they propose as a working hypothesis that "in grammatical sub-systems with a clear referential basis like person, the definitions of the persons should be constant across languages" (Vincent and Börjars 2007, pages 301–302). The issue of *the relation between syntax and meaning* is whether and to what extent the complex value of a syntactic feature like PERS reflects details of the meaning of the form with which it is associated. In a language like English, the first person plural pronoun *we* can be used to refer to the speaker and the hearer (an inclusive reading) or to the speaker and another person (an exclusive reading); prioritizing a transparent relation between syntax and meaning entails that this meaning distinction should be encoded as a syntactic ambiguity in the f-structural representation, even if there is no morphological or syntactic evidence for this ambiguity. On the basis of these motivations, Vincent and Börjars (2007) argue that the more complex system in (156) is universal, and relevant for languages like English in addition to languages like Fula.

Sadler (2011) observes that set-based analyses of complex feature values can be directly translated to equivalent feature-based analyses, with a positive value representing the presence of an element in the set, and a negative value representing its absence (see Chapter 6, Section 3.4). Otoguro (2015) proposes a feature-based analysis of the PERS feature in his analysis of PERS agreement in Germanic and Romance:

(157) Values for the PERS feature according to Otoguro (2015):

First person: $\left[\text{PERS} \begin{bmatrix} 1 & + \\ 2 & - \end{bmatrix}\right]$

Second person: $\left[\text{PERS} \begin{bmatrix} 1 & - \\ 2 & + \end{bmatrix}\right]$

Third person: $\left[\text{PERS} \begin{bmatrix} 1 & - \\ 2 & - \end{bmatrix}\right]$

According to Otoguro's analysis, first person is represented with two features, [1 +] and [2 −]. This corresponds to the first-person exclusive value in (156), with the attribute 1 corresponding to S, the attribute 2 corresponding to H, the value + corresponding to the presence of an element in the set, and the value − corresponding to its absence. An additional value [1 +, 2 +] could be added for first-person inclusive. Notably, unlike a set-based analysis, a feature-based analysis allows underspecification: a first-person pronoun in a language like English, with no inclusive/exclusive distinction, can be represented simply as [1 +]. Similarly, forms that are compatible with either second or third person (as in the Rongpo verbal paradigm in 116) require [1 −], but are unspecified for the 2 feature or its value: this means that they are compatible with additional specification as either second person ([1 −, 2 +]) or third person ([1 −, 2 −]).

5.7.3. GENDER

Many LFG analyses assume simple atomic values for the GEND feature:

(158) Simple atomic values for the feature GEND: M (masculine), F (feminine), N (neuter)...

However, analyses of syntactic gender resolution often depend on a complex value for the GEND feature. For example, gender resolution in Icelandic obeys the following rule (Corbett 1983):

(159) Gender resolution in Icelandic:

If the conjuncts are all masculine, the masculine form is used.

If the conjuncts are all feminine, the feminine form is used.

Otherwise the neuter form is used.

This is shown in example (160), where mixed-gender coordinate phrases control neuter agreement (Dalrymple and Kaplan 2000):

(160) a. *[Drengurinn og telpan] eru þreytt.*
the.boy.M and the.girl.F are tired.N
'The boy and the girl are tired.'

b. *[Maðurinn og barnið] eru þreytt.*
the.man.M and the.baby.N are tired.N
'The man and the baby are tired.'

c. *Ég sá [á og lamb], bæði svört.*
I saw a.ewe.F and a.lamb.N both black.N
'I saw a ewe and a lamb, both black.'

The generalization in (159) can be restated as:

(161) Icelandic:

masculine & masculine	=	masculine
feminine & feminine	=	feminine
neuter & neuter	=	neuter
masculine & feminine	=	neuter
masculine & neuter	=	neuter
feminine & neuter	=	neuter

Dalrymple and Kaplan (2000) propose that the value of the GEND feature is a closed set containing members like M and F, and that, as in their analysis of person resolution, gender resolution is modeled as set union. For Icelandic, they propose the GEND values in (162):

(162) Values for the GEND feature in Icelandic according to Dalrymple and Kaplan (2000):

masculine	{M}
feminine	{F}
neuter	{M, F}

Given these values, modeling gender resolution as set union produces the correct result, as can be seen by comparing the tables in (161) and (163):

(163) Resolution of the GEND feature as set union (Dalrymple and Kaplan 2000):

{M} (masculine) ∪ {M} (masculine)	=	{M} (masculine)
{F} (feminine) ∪ {F} (feminine)	=	{F} (feminine)
{M, F} (neuter) ∪ {M, F} (neuter)	=	{M, F} (neuter)
{M} (masculine) ∪ {F} (feminine)	=	{M, F} (neuter)
{M} (masculine) ∪ {M, F} (neuter)	=	{M, F} (neuter)
{F} (feminine) ∪ {M, F} (neuter)	=	{M, F} (neuter)

Vincent and Börjars (2007) also propose an analysis using sets in the representation of the value of the GEND feature, but object to the gender values that Dalrymple and Kaplan present, and to the use of set union to model gender resolution. They observe that Dalrymple and Kaplan's analysis of gender violates the *markedness* criterion discussed in Section 5.1, according to which the formally more marked value of a feature should behave as the more marked member in an opposition of feature values. In Icelandic, neuter is the unmarked gender value; however, in Dalrymple and Kaplan's system, neuter is formally the most marked, since it is represented as a set with two members (M and F), while the masculine and feminine values each contain one member and so are less formally marked.

Vincent and Börjars (2007, page 297) propose as a desideratum for the formal representation of complex feature values that "for whatever morphosyntactic sub-system we examine, we must be able to show by independent tests that the member of that system which is assigned the representation { } acts as the unmarked form". They propose the values given in (164) for the GEND feature in Icelandic:

(164) Values for the GEND feature in Icelandic according to Vincent and Börjars (2007):

masculine	{M}
feminine	{F}
neuter	{ }

Here the unmarked form is the neuter value, represented as the empty set { }, as desired. As Vincent and Börjars observe, these values allow for a pleasingly simple generalization about gender resolution in Icelandic and many other languages: for conjuncts of different genders, agreement is with the unmarked form, represented as { }. Crucially, however, under these assumptions it is necessary to model gender resolution by set intersection (∩) rather than set union (∪):[40]

(165) Resolution of the GEND feature as set intersection (Vincent and Börjars 2007):

$$
\begin{array}{rl}
\{\textsc{m}\}\ (\text{masculine}) \cap \{\textsc{m}\}\ (\text{masculine}) & = \{\textsc{m}\}\ (\text{masculine})\\
\{\textsc{f}\}\ (\text{feminine}) \cap \{\textsc{f}\}\ (\text{feminine}) & = \{\textsc{f}\}\ (\text{feminine})\\
\{\ \}\ (\text{neuter}) \cap \{\ \}\ (\text{neuter}) & = \{\ \}\ (\text{neuter})\\
\{\textsc{m}\}\ (\text{masculine}) \cap \{\textsc{f}\}\ (\text{feminine}) & = \{\ \}\ (\text{neuter})\\
\{\textsc{m}\}\ (\text{masculine}) \cap \{\ \}\ (\text{neuter}) & = \{\ \}\ (\text{neuter})\\
\{\textsc{f}\}\ (\text{feminine}) \cap \{\ \}\ (\text{neuter}) & = \{\ \}\ (\text{neuter})
\end{array}
$$

As mentioned above and discussed in more detail in Chapter 6, Section 3.4, Sadler (2011) demonstrates that set-based analyses of complex feature values have a ready translation to feature-based analyses. She provides a feature-based analysis of Icelandic gender which conforms to Vincent and Börjars's observations about markedness if we assume that a negative value for a feature corresponds to the unmarked value for that feature.

[40] Relations between sets, including set union and set intersection, are defined and discussed in Chapter 6, Section 3.

5.7.4. Number

In much LFG work, the number feature is assumed to have atomic values such as SG, DU, PAUCAL, and PL:

(166) Simple atomic values for the feature NUM: SG (singular), DU (dual), PAUCAL (paucal), PL (plural)

However, patterns involving *constructed number* are often taken as evidence that the value of the NUM feature is not atomic, but a complex value whose form may be constrained in different ways by different parts of the sentence. As briefly discussed in Section 5.1, Sadler (2011) provides an analysis of the constructed dual in Hopi which assumes a complex value for the NUM feature. Example (118), repeated here, illustrates the Hopi patterns:

(167) a. *Pam wari*
that.SG run.NONPL
'S/he ran.'

b. *Puma yùutu*
that.NONSG run.PL
'They ran.'

c. *Puma wari*
that.NONSG run.NONPL
'They (two) ran.'

Sadler proposes the following complex values for the NUM feature:

(168) Values for the NUM feature according to Sadler (2011):

Singular: $\left[\text{NUM} \begin{bmatrix} \text{SG} & + \\ \text{PL} & - \end{bmatrix}\right]$

Dual: $\left[\text{NUM} \begin{bmatrix} \text{SG} & + \\ \text{PL} & + \end{bmatrix}\right]$

Plural: $\left[\text{NUM} \begin{bmatrix} \text{SG} & - \\ \text{PL} & + \end{bmatrix}\right]$

Crucially, according to Sadler's analysis, number may be partially specified by different components of the sentence; as long as the partial specifications are compatible, the sentence is wellformed. For example, the demonstrative *puma* is specified as nonsingular, with a [PL +] specification but no specification for the SG feature; the verb *wari* is specified as nonplural, with a [SG +] specification but no specification for the PL feature. This allows the complex value for the NUM feature to be constructed by combining the NUM of the subject and the NUM of the verb; in (169c), dual number results from the compatible partial specifications on the subject and the verb:

(169) a. *Pam* *wari*
that.SG run.NONPL
[SG +, PL −] [PL −]
'S/he ran.' (singular: [SG +, PL −])

b. *Puma* *yùutu*
that.NONSG run.PL
[PL +] [SG −, PL +]
'They ran.' (plural: [SG −, PL +])

c. *Puma* *wari*
that.NONSG run.NONPL
[PL +] [SG +]
'They (two) ran.' (dual: [SG +, PL +])

Arka (2011, 2012) also proposes a feature-based analysis for constructed number in Marori, and Jones (2015a,b) proposes a feature-based analysis for the complex number system of Meryam Mir. Interestingly, Nordlinger (2012) presents a detailed examination of the number system of Murrinh-Patha, arguing that the complex patterns of number marking in that language are not best analyzed in terms of a feature-based treatment of the NUM feature such as Sadler, Arka, and Jones propose.

We know of no set-based proposals for the value of the number feature, and indeed it is not clear that it would be possible to formulate an analysis of the number of coordinate noun phrases that could take advantage of the set-based operations of union or intersection that have been proposed for PERS resolution (Section 5.7.2) or GEND resolution (Section 5.7.3). If we assume a set-based representation of the NUM feature, and we assume that the NUM value for a coordinate structure is determined by set union or set intersection, as for PERS and GEND, we would incorrectly expect a coordinate structure with two singular conjuncts to be singular: no matter what set we choose to represent the singular value for the NUM feature, the union of any set with itself is that set, and the intersection of any set with itself is also that set. In fact, however, a coordinate structure such as *David and Chris*, with singular conjuncts, has plural number and not singular number; set union and intersection do not provide a straightforward foundation for a theory of number in coordinate structures. Dalrymple (2012) provides a general overview of issues related to the treatment of the NUM feature and the representation of its value in LFG.

The Bosnian/Croatian/Serbian example discussed in Section 5.7.1 shows that the same noun phrase can control different values for the NUM feature on different agreement targets. Mittendorf and Sadler (2005) present two alternative analyses of number mismatch in Welsh NPs: one analysis assumes a complex f-structure, and the other relies on the INDEX/CONCORD distinction and the possibility for the NUM feature to be specified differently for INDEX and CONCORD. Hristov (2012) proposes an analysis of nouns which seem to exhibit both singular and plural properties, such as British English "company", which require singular determiners but can appear with plural verbs (as in the attested example *This company* *are superbly managed*: Hristov 2012, page 174). Wechsler (2011) proposes that some agreement mismatches can be driven by the absence of syntactic agreement features on the controller (see also Wechsler and Hahm 2011); this is his *Agreement Marking Principle*, informally stated in (170):

(170) Agreement Marking Principle (Wechsler 2011, page 1009):

> Agreement is driven by a syntactic feature of the controller, if the controller has such a feature. If the controller lacks such a feature, then the target agreement inflection is semantically interpreted as characterizing the controller denotation.

In support of this view, Wechsler (2011) discusses the French examples in (171), in which the verb *êtes* displays syntactic (second person plural) INDEX agreement with the pronominal subject *vous* 'you' whether the subject is semantically singular (as in example 171a, exemplifying the polite plural use of the pronoun) or semantically plural (as in 171b), while the predicate adjective displays semantic agreement (singular in 171a), plural in 171b). Wechsler proposes that the French pronoun *vous* does not bear CONCORD features, and so there are no syntactic features to control agreement with the predicate adjective; in this situation, the Agreement Marking Principle correctly predicts that the adjective agreement features reflect semantic features of the controller.

(171) a. *Vous êtes loyal.*
you.PL be.2PL loyal.M.SG
'You (singular, formal, male) are loyal.'

b. *Vous êtes loyaux.*
you.PL be.2PL loyal.PL
'You (plural) are loyal.'

In Bosnian/Croatian/Serbian, as in French, the auxiliary verb shows second person plural INDEX agreement with the pronoun *vi* 'you'. Unlike French, however, the predicative adjective shows plural and not singular agreement, even when the subject refers to a single individual:

(172) *Vi ste duhovit-i.*
you.PL AUX.2.PL funny-M.PL
'You (one formal addressee/multiple addressees) are funny.'

According to Wechsler (2011), this indicates that the Bosnian/Croatian/Serbian pronoun *vi* differs from French *vous* in being specified for CONCORD as well as INDEX features: the pronoun *vi* has plural CONCORD, controlling plural agreement on the predicate adjective.

5.7.5. CASE

A great deal of work in LFG has been done on the morphosyntax of case. Butt and King (2004b) discuss the kinds of syntactic relations that can be marked by case: *semantic case* and *quirky case* can appear on either terms or obliques, and *structural case* and *default case* appear on terms. Otoguro (2006) discusses the theoretical status of case, illustrating his discussion with examples from Icelandic, Hindi-Urdu, and Japanese. For a thorough and wide-ranging overview of case and its role in grammar, see Butt (2006); for a detailed discussion of case in an LFG setting, see Butt (2008).

We have seen that features such as INDEX must be treated as nondistributive, since a coordinate structure has its own value for INDEX features which is determined by rules referring to the value of the INDEX features of the conjuncts. A distinguishing characteristic of nondistributive features, including the components of the INDEX feature, is that for any resolving feature and any combination of features of the conjuncts, there is a means of determining the resolved value of the feature for the coordinate structure. As a component of the CONCORD feature bundle, the CASE feature behaves differently, in that there are no resolution rules for case: that is, there is no sense in which different values for the case feature systematically combine to determine a resolved case value for the coordinate structure. In fact, coordinate structures in which the conjuncts have mismatching case values are often unacceptable, and this is predicted if we treat CASE as a distributive feature, as we discuss in Chapter 6, Section 3.2.2. For example, if we assume that the CONCORD feature is distributive and that subjects must bear nominative CASE, we predict that each conjunct in a coordinate subject phrase must specify nominative case in its CONCORD feature bundle. However, the situation is in fact more complex: Peterson (2004a) and Hristov (2012, Chapter 5; 2013b) argue that CASE in English is best treated as a nondistributive feature, in light of attested examples exhibiting case mismatch such as *...[him and I] have this fight, right?*, from the British National Corpus, and Patejuk (2015) provides further discussion of CASE mismatches in coordinate structures in Polish. In this book we provisionally treat CONCORD and its component CASE feature as a distributive feature, but further research may show the need for treating it instead as a nondistributive feature, and analyzing its behavior in coordination by means of constraints on the relation between the CONCORD value of the coordinate structure and the CONCORD values of the conjuncts.

Simple values such as those listed in (173) are often assumed for the CASE feature:

(173) Simple atomic values for the feature CASE: NOM (nominative), ACC (accusative) ERG (ergative), ABS (absolutive), GEN (genitive), LOC (locative), DAT (dative), ABL (ablative), INS (instrumental)...

This simple representation does not allow for a treatment of *case indeterminacy* (Groos and van Reimsdijk 1979; Zaenen and Karttunen 1984), where a form with underspecified case can satisfy more than one case requirement at the same time. The German nouns *Männer*/*Männern* ‘men’ and *Papageien* ‘parrots’ differ in the cases that they express:

(174) a. Papageien
‘parrots.NOM/ACC/DAT/GEN’

b. Männer
‘men.NOM/ACC/GEN’

c. Männern
‘men.DAT’

As noted in Section 5.1, *Papageien* but not *Männer* or *Männern* can appear as the shared object of coordinated verbs if one verb requires accusative case and the other requires dative case (175c). Example (175) shows that the verb *findet* ‘find’ requires an accusative object (175a), while the verb *hilft* ‘helps’ requires a dative object (175b) (Pullum and Zwicky 1986):

(175) a.

Er findet	*Papageien* /	*Männer* /	**Männern.*
he finds	parrots	men	men
OBJ:ACC	NOM/ACC/DAT/GEN	NOM/ACC/GEN	DAT

‘He finds parrots/men.’

b.

Er hilft	*Papageien* /	**Männer* /	*Männern.*
he helps	parrots	men	men
OBJ:DAT	NOM/ACC/DAT/GEN	NOM/ACC/GEN	DAT

‘He helps parrots/*men.’

c.

Er findet	*und hilft*	*Papageien* /	**Männer* /	**Männern.*
he finds	and helps	parrots	men	men
OBJ:ACC	OBJ:DAT	NOM/ACC/DAT/GEN	NOM/ACC/GEN	DAT

‘He finds and helps parrots/*men.’

Dalrymple and Kaplan (2000) propose to represent the value of the CASE feature of a nominal as a set whose members are the case values that the nominal can express. A verb taking an accusative object requires ACC to be a member of the CASE set of its object, and similarly for a verb taking a DAT object:[41]

(176) Set-based analysis of indeterminate case according to Dalrymple and Kaplan (2000):

Er findet	*und hilft*	*Papageien.*
he finds	and helps	parrots
ACC ∈ OBJ CASE	DAT ∈ OBJ CASE	[CASE {NOM,ACC,DAT,GEN}]

‘He finds and helps parrots.’

This treatment is adequate for simple cases of indeterminacy, but Dalrymple et al. (2009) show that it does not make correct predictions for some more complex

[41]The symbol ∈ is the set-membership predicate: $a \in S$ means that a is a member of the set S. See Chapter 6, Section 3.

cases. They examine the *transitivity problem* (where a modifier restricts the possibilities for case expression of its head noun) and the *second-order indeterminacy problem* (where a predicate imposes indeterminate requirements on an argument which may itself be indeterminately specified); see Dalrymple et al. (2009) for detailed discussion of these issues, and a demonstration that a feature-based approach with underspecification solves both of these problems. Dalrymple et al. propose the following representation for the determinate dative case value for a noun like *Männern*:

(177) Determinate DAT case for *Männern* according to Dalrymple et al. (2009):

$$\begin{bmatrix} \text{CASE} & \begin{bmatrix} \text{NOM} & - \\ \text{ACC} & - \\ \text{GEN} & - \\ \text{DAT} & + \end{bmatrix} \end{bmatrix}$$

Predicates specify a positive value for the case that they require: for example, a predicate requiring dative case specifies [DAT +] for its argument. Indeterminate nouns like *Männer* and *Papageien* are underspecified; they can be assigned a value of + for one or more case features, as long as the value of the feature is not already specified as −. For clarity of exposition, we explicitly represent all case features in (178) and (179), with a blank value for features with no assigned value.

(178) a. Indeterminate NOM/ACC/GEN case for *Männer* according to Dalrymple et al. (2009):

$$\begin{bmatrix} \text{CASE} & \begin{bmatrix} \text{NOM} & \\ \text{ACC} & \\ \text{GEN} & \\ \text{DAT} & - \end{bmatrix} \end{bmatrix}$$

b. Completely indeterminate case specification for *Papageien* according to Dalrymple et al. (2009):

$$\begin{bmatrix} \text{CASE} & \begin{bmatrix} \text{NOM} & \\ \text{ACC} & \\ \text{GEN} & \\ \text{DAT} & \end{bmatrix} \end{bmatrix}$$

(179) Feature-based analysis of indeterminate case according to Dalrymple et al. (2009):

Er findet *und hilft* *Papageien.*
he finds and helps parrots
OBJ: [CASE [ACC +]]] OBJ: [CASE [DAT +]]] $\left[\text{CASE} \begin{bmatrix} \text{NOM} & \\ \text{ACC} & + \\ \text{GEN} & \\ \text{DAT} & + \end{bmatrix}\right]$

'He finds and helps parrots.'

Complex values for the CASE feature (whether set-based or feature-based) bear a superficial resemblance to the complex values of the PERS, NUM, and GEND features; importantly, however, they express very different linguistic intuitions, despite their formal similarity. For indeterminate features like CASE, a complex value such as {NOM,ACC} or [NOM +, ACC +] enumerates a set of alternative possibilities which may be simultaneously realized, allowing an indeterminate form to simultaneously fulfill conflicting case requirements. In contrast, the specification of the dual value of the NUM feature as [SG +, PL +] does not entail that dual nouns are in any sense simultaneously SG and PL, or alternately SG or PL with respect to different predicates; instead, complete patterns of values of the PERS, NUM, and GEND features holistically represent the values for these features.

5.7.6. Nominal Specification and Quantification

The function SPEC has been used in the analysis of articles such as *the* and *a* as well as quantifiers and occasionally possessors, thus grouping together elements which "specify" rather than modify the head in a nominal phrase. Sadler (2000) and Falk (2002a) note that treating both possessors and articles as contributing a value of the SPEC attribute makes it difficult to analyze languages which allow both an article and a possessor in the same nominal phrase; Falk (2002a) provides example (180) to show that the definite article is obligatory in Romanian noun phrases containing a possessor:[42]

(180) a. *cas-a* *unei* *vecine*
house-the a.GEN neighbor
'a neighbor's (the) house'

b. **casă* *unei* *vecine*
house a.GEN neighbor
'a neighbor's house'

The article and the possessor cannot both contribute values for the same SPEC attribute in examples like (180): either the article or the possessor must contribute a value for an attribute other than SPEC. As discussed in Section 1.10, we adopt the POSS grammatical function for possessors.

Similarly, English noun phrases can contain both an article and a quantifier:

[42] Falk attributes example (180) to Dobrovie-Sorin (2001).

(181) a. *the many dogs*

b. *those few cats*

Therefore, we also need separate attributes for the contributions of articles and quantifiers.

We make use of the features DEF, DEIXIS, and SPEC for nominal f-structures. In English, the value for the feature DEF is either + or −:

(182) Values for the feature DEF: + (definite), − (indefinite)

Demonstrative determiners like *this* and *those* are definite, contributing the value + for the DEF feature, as well as contributing a DEIXIS feature. The English deictic system makes only a two way proximal/distal distinction. The deictic systems of other languages are more complex, including additional values such as MEDIAL:

(183) Values for the feature DEIXIS: PROX (proximal), MEDIAL (medial), DIST (distal)...

There is an important difference between articles like *the* and quantifiers like *every* or *all*: articles cannot be modified (**almost the*), but quantifiers can be (*almost every*). This means that a quantifier must contribute not an atomic value for a feature, but an f-structure with its own PRED attribute and semantic form value, in which an ADJ attribute can also appear:

(184) a. *every*:

$$\begin{bmatrix} \text{PRED} & \text{`EVERY'} \end{bmatrix}$$

b. *almost every*:

$$\begin{bmatrix} \text{PRED} & \text{`EVERY'} \\ \text{ADJ} & \left\{ \begin{bmatrix} \text{PRED} & \text{`ALMOST'} \end{bmatrix} \right\} \end{bmatrix}$$

Therefore, the value for the feature SPEC is an f-structure whose semantic form represents the quantifier:

(185) Values for the feature SPEC: f-structures with semantic form 'ALL', 'EVERY', 'BOTH'...

5.7.7. PRONTYPE

The PRONTYPE feature marks the type of a pronominal f-structure. The type of a pronoun is syntactically constrained in a number of constructions: a complex fronted phrase in a relative clause must contain a relative pronoun with type REL; the subject of a tag question such as *isn't it?* or *aren't they?* in standard English must be a personal pronoun (PERS); verbs such as *perjure (oneself)* require a nonthematic reflexive pronominal object (REFL), and so on. To account for these requirements, PRONTYPE must be marked in the f-structure. We assume the following values for the feature PRONTYPE:

(186) Values for the feature PRONTYPE: REL (relative pronoun), WH (interrogative pronoun), PERS (personal pronoun), REFL (reflexive pronoun), RECP (reciprocal pronoun)

5.8. Summary: Functional Features

Our discussion has focused primarily on the features that play a role in the functional syntax of English. Many of these features are also relevant for other languages, but some languages may make more or fewer distinctions in the values of these features, and other languages may not make any use of these features in their functional syntax. It is important to examine the feature system of each language carefully in order to determine the inventory of functional features and values that are appropriate for that language.

We have seen that the features in (187) have simple atomic values:

(187) F-structure features with atomic values:

	Feature	Value
Form features (Section 5.3)	FORM	Surface word form
	PFORM	Form of the preposition
	COMPFORM	Form of the complementizer: THAT, WHETHER, IF...
Prepositional "case" (Section 5.4)	PCASE	The family of grammatical functions OBL_θ
Verbal and clausal features (Section 5.5)	VTYPE	FIN, PRS.PTCP, PST.PTCP, INF...
	MOOD	IND, IMP, SBJV, INTERR...
	VOICE	PASS, ANTIP, MID, DIR, INV, AV, OV, DV, IV, BV...
Nominal features (Section 5.7)	DEF	$+, -$
	PRONTYPE	REL, WH, REFL, PERS...
	DEIXIS	PROX, MEDIAL, DIST...

The features in (188) have been argued to have complex values, at least in some languages. For details of the complex value of the feature, see the indicated section. As discussed in Section 5.1, we often use atomic abbreviations for these complex values when the details of the representation of the feature are not important to the issues under discussion, and it is these abbreviations which appear in (188).

(188) Abbreviations for complex f-structure values:

	Feature	Abbreviated Value
Verbal and clausal features	TENSE	PRS, PST, FUT. . . (see Section 5.5.1)
	ASPECT	simple values: PRF, PROG, IPRF, IPFV, PFV; complex values are represented by combining simple values: PRF.PROG. . . (see Section 5.5.2)
Nominal features	PERS	1, 2, 3 (see Section 5.7.2)
	GEND	M, F, N. . . (see Section 5.7.3)
	NUM	SG, DU, PL. . . (see Section 5.7.4)
	CASE	NOM, ACC, DAT, ERG, ABS, GEN, ABL, LOC, INS, PART. . . (see Section 5.7.5)

Features can also be cross-classified in several ways. Section 5.7.1 discussed two kinds of nominal features, INDEX and CONCORD features:

(189) INDEX features: PERS, NUM, GEND

CONCORD features: NUM, GEND, CASE

The features NUM and GEND appear in both feature bundles, and in fact they can take on different values in each feature bundle: for example, as shown in example (149) of this chapter, the Bosnian/Croatian/Serbian noun *dobra* 'children' has singular CONCORD, but plural INDEX.

In Section 4.5, we demonstrated the need to distinguish betwen *distributive* and *nondistributive* features in coordinate structures. We assume that the only nondistributive features are INDEX (specifying the resolved PERS, NUM, and GEND features of coordinate noun phrases), ADJ (specifying modifiers of coordinate structures in examples like *David yawned and sneezed simultaneously*, where *simultaneously* modifies the coordinated verbs *yawned and sneezed*), and CONJ and PRECONJ (specifying the form of the conjunction and preconjunction). We return to a discussion of distributive and nondistributive features in Chapter 6, Section 3.2 and Chapter 16.

(190) Nondistributive features: INDEX, ADJ, CONJ, PRECONJ

Distributive features: all other features, including PRED and the governable grammatical functions

Example f-structures for a range of simple English nominal phrases are given in (191). Recall that SG and PL are abbreviations standing for complex values for the NUM feature, as discussed in Section 5.7.4, and similarly for the simple abbreviatory values presented in (191k) for the CASE, PERS, and GEND features. We omit CONCORD features in most of the examples.

(191) a. *a dog:*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{dog}\text{'} \\ \textsc{def} & - \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{sg} \end{bmatrix} \end{bmatrix}$$

b. *the dog:*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{dog}\text{'} \\ \textsc{def} & + \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{sg} \end{bmatrix} \end{bmatrix}$$

c. *this dog:*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{dog}\text{'} \\ \textsc{def} & + \\ \textsc{deixis} & \textsc{prox} \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{sg} \end{bmatrix} \end{bmatrix}$$

d. *that dog:*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{dog}\text{'} \\ \textsc{def} & + \\ \textsc{deixis} & \textsc{dist} \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{sg} \end{bmatrix} \end{bmatrix}$$

e. *every dog:*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{dog}\text{'} \\ \textsc{spec} & \begin{bmatrix} \textsc{pred} & \text{`}\textsc{every}\text{'} \end{bmatrix} \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{sg} \end{bmatrix} \end{bmatrix}$$

f. *all dogs:*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{dog}\text{'} \\ \textsc{spec} & \begin{bmatrix} \textsc{pred} & \text{`}\textsc{all}\text{'} \end{bmatrix} \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{pl} \end{bmatrix} \end{bmatrix}$$

g. *all the dogs:*

$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{dog}\text{’} \\ \textsc{spec} & \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{all}\text{’} \end{bmatrix} \\ \textsc{def} & + \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{pl} \end{bmatrix} \end{bmatrix}$$

h. *both the dogs:*

$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{dog}\text{’} \\ \textsc{spec} & \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{both}\text{’} \end{bmatrix} \\ \textsc{def} & + \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{pl} \end{bmatrix} \end{bmatrix}$$

i. *the many dogs:*

$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{dog}\text{’} \\ \textsc{spec} & \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{many}\text{’} \end{bmatrix} \\ \textsc{def} & + \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{pl} \end{bmatrix} \end{bmatrix}$$

j. *David’s dog:*

$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{dog}\text{’} \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{sg} \end{bmatrix} \\ \textsc{poss} & \begin{bmatrix} \textsc{pred} & \text{‘David’} \end{bmatrix} \end{bmatrix}$$

k. *his dog:*

$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{dog}\text{’} \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{sg} \end{bmatrix} \\ \textsc{poss} & \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{pro}\text{’} \\ \textsc{prontype} & \textsc{pers} \\ \textsc{concord} & \begin{bmatrix} \textsc{case} & \textsc{gen} \end{bmatrix} \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 3 \\ \textsc{num} & \textsc{sg} \\ \textsc{gend} & \textsc{m} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

6. FURTHER READING AND RELATED ISSUES

Within LFG, there has been more discussion of grammatical functions and functional structure than can be summarized in a brief space. Bresnan et al. (2016, Chapter 6) provide an in-depth discussion of the classification of grammatical functions. In their lucid summary of LFG theory, Asudeh and Toivonen (2015, page 380) provide a useful table of grammatical functions with illustrative examples, reprinted in Bresnan et al. (2016, page 99). Alsina (1996), Przepiórkowski (2017), and Patejuk and Przepiórkowski (2017) argue for a more restricted inventory of grammatical functions than is assumed in these works and in this book. Duncan (2007) discusses the argument-adjunct distinction, as does Rákosi (2006b); for more on this issue see Chapter 9, Section 10.5.2. Andrews (2007a) provides a good overview of the grammatical functions of nominals. The grammatical function of incorporated nouns is discussed in Asudeh (2007) and Duncan (2007). On double object constructions and the challenges that they present to LFG treatments of objecthood, see Lam (2008) and Thomas (2012). On the $\textsc{obj}/\textsc{obj}_\theta$ distinction in Indonesian, see Musgrave (2008). Allen (2001) analyzes the development of the recipient passive as involving reanalysis of grammatical functions, from $\textsc{obj}_{\textsc{recipient}}$ and $\textsc{obj}$ in Old English to $\textsc{obj}$ and $\textsc{obj}_{\textsc{theme}}$ respectively in Modern English. Butt et al. (1999) provide a general overview of English, French, and German functional and phrasal structure, and Dipper (2003) provides a computationally-oriented discussion of the syntactic structure of the German nominal phrase.

3

CONSTITUENT STRUCTURE

We have seen that there is a large degree of unity in the abstract functional syntactic structure of languages. In contrast, phrasal structure varies greatly: some languages allow phrases with no lexical heads, and some have no such categories; some languages have a VP constituent, and others do not; and so on. In this chapter, we will discuss the organization of overt phrasal syntactic representation, the *constituent structure* or *c-structure*. We will explore commonalities in constituent structure across the world's languages, and talk about how languages can differ in their phrasal organization. We will also consider the relation between phrasal syntactic structure and the surface linear order of syntactic units; we consider the surface linear order to be a separate level of representation, the *syntactic string* or *s-string*.

Section 1 of this chapter begins by discussing some traditional arguments for constituent structure representation. Many of these arguments turn out to be flawed, since the theory of phrase structure has a different status in LFG than in theories in which grammatical functions are defined configurationally and abstract syntactic (and even semantic and information structural) relations are represented in phrase structure terms. Some arguments for particular phrase structure theories and configurations are based on phenomena which in LFG are better treated in other structures, such as f-structure, and do not constitute good arguments for constituent structure at all. For this reason, we must examine the status of arguments for and against particular phrase structures or phrase structure theories particularly carefully. Section 2 proposes some valid criteria within LFG for phrase structure determination.

Research on constituent structure has revealed much about the universally available set of categories and how they can combine into phrases. We adopt a view of phrase structure that incorporates insights primarily from the work of Kroeger (1993), King (1995), Sadler (1997), Sells (1998), Toivonen (2003), and Bresnan et al. (2016). We assume lexical categories like N and V, as well as functional categories like I and C. These categories appear as the heads of phrases like NP and IP; the inventory of constituent structure categories that are crosslinguistically available and the theory of the organization of words and categories into phrases are explored in Section 3. The general theory of constituent structure organization is exemplified in Section 4, where we provide more specific discussion of the constituent structure organization of clauses and the role of the functional categories I and C in clausal structure. In Section 5 we discuss the relation between hierarchical constituent structure and surface linear order.

1. TRADITIONAL ARGUMENTS FOR CONSTITUENT STRUCTURE

The sorts of constituent structure rules and representations used in LFG and most other theories of constituent structure are prefigured in work by Bloomfield (1933), who assumes complex phrasal structures described in terms of "immediate constituent analysis": the combination of words into phrases. These structures were originally motivated within the transformational tradition by the desire to formulate a finite characterization of the infinite set of sentences of a language. As Chomsky (1955, page 116) says:

> If there were no intervening representations between *Sentence* and words, the grammar would have to contain a vast (in fact, infinite) number of conversions of the form *Sentence*→*X*, where *X* is a permissible string of words. However, we find that it is possible to classify strings of words into phrases in such a way that sentence structure can be stated in terms of phrase strings, and phrase structure in terms of word strings, in a rather simple way. Further, a phrase of a given type can be included within a phrase of the same type, so that a finite number of conversions will generate an infinite number of strings of words.

Chomsky's first point is that the same sequence of categories may appear in more than one environment, and any adequate grammar must characterize this regularity. For instance, the phrase *the dachshund* can appear in many positions in a sentence:

(1) a. *The dachshund is barking.*

b. *David petted the dachshund.*

c. *Matty gave a treat to the dachshund.*

No matter where it appears, it can be replaced by a phrase with additional modifiers:

(2) a. *The black dachshund is barking.*

b. *David petted the black dachshund.*

c. *Matty gave a treat to the black dachshund.*

Generalizations about the structure of the phrase *the dachshund* and the phrases that can be substituted for it are captured by assuming that *the dachshund* is a noun phrase and can appear wherever other noun phrases can appear. This is intuitively appealing, since it captures the intuition that *the dachshund* (and *the black dachshund*) are phrasal units in a sense that *dachshund is* or *petted the* are not. Further, it simplifies the linguistic description: the different ways in which a noun phrase can be formed do not have to be separately enumerated for each environment in which a noun phrase can appear.

Chomsky's second point is that a phrase may contain subconstituents of the same type: a clause can contain a subordinate clause, a noun phrase can contain other noun phrases, and so on. Our linguistic descriptions therefore need the same kind of recursive character.

This formal motivation for a level of constituent structure analysis and representation is buttressed by a range of diagnostics for phrase structure constituency. However, current syntactic theories vary greatly in their criteria for determining the validity of these diagnostics, and tests that are accepted in some theoretical frameworks are not recognized as valid in other frameworks. For instance, Chomsky (1981) and work growing out of the transformationally based theory presented there (see, for example, Webelhuth 1995; Rizzi 1997; Chomsky 2001; Adger 2003) propose that abstract syntactic properties and relations are represented in terms of phrase structure trees, and that relations between these trees are statable in terms of the movement of constituents ("move-α", Move, or Internal Merge). In fact, in such work not only syntactic relations, but also semantic and information structural properties and relations, are represented in phrase structure terms. Given such a theory, the criterion for constituenthood is fairly straightforward: any unit that plays a role in abstract syntactic structure, semantic structure, or information structure is a phrase structure constituent, since it must be represented as a unit and must be eligible to undergo movement.

Such criteria have no relevance in a theory like LFG. We have seen that abstract syntactic structure is represented by functional structure, not in phrasal terms; further, phrase structural transformations and movement rules play no role in LFG theory. We will see in Part II (Chapter 7 to Chapter 12) that semantic and information structural features, as well as other non-syntactic aspects of grammar, are likewise represented by separate structures in LFG. LFG's constituent structure trees represent tangible phrasal configurations, not more abstract relations. Thus, many criteria commonly proposed within the transformational tradition to identify phrase structure constituents turn out to be irrelevant in an LFG setting.

In this light, it is interesting to carefully examine one detailed proposal for testing constituency within a transformationally based theory. Radford (2009, pages 58–69) discusses a set of tests for constituency, including the following:

(3) (i) Coordination: a constituent can be coordinated with another similar constituent.

(ii) Ellipsis: only (some) constituents can be omitted, under appropriate discourse conditions.

(iii) Substitution: a constituent can be replaced by, or serve as the antecedent of, a proform.

(iv) The fragment test: only (some) constituents can serve as sentence fragments (that is, valid free-standing expressions that are not complete sentences).

Test (i), coordination, proves not to be very successful. It is well known that many strings that are shown not to be constituents by other criteria can be coordinated:

(4) a. *David gave [a flower] [to Chris] and [a book] [to Pat].*

b. *[David] [likes], and [Chris] [dislikes], carrots.*

On most theories of the constituent structure of English, the phrases *a flower to Chris* and *David likes* are not constituents. It does seem to be true, at least in English, that if a string is a constituent it can be coordinated, barring semantic unacceptability, but the converse implication, that if a string can be coordinated it is a constituent, does not hold.[1]

Test (ii), ellipsis, is also relatively unsuccessful. Many constituents cannot be omitted:

(5) a. *Chris told me that David yawned.*

b. **Chris told that David yawned.*

c. **Told me that David yawned.*

At the same time, sequences that are not constituents can be omitted:

(6) *Chris can write better plays than David (can write) novels.*

Even if, as Radford argues, this example involves two separate omitted constituents, *can* and *write*, the usefulness of this test for determining constituency is seriously undermined. The same problem applies to test (iii), substitution. Many constituents cannot be replaced by a proform:

(7) a. *Chris gave a book [to David].*

[1] See Chapter 16 for discussion of coordination in general and nonconstituent coordination in particular.

b. **Chris gave a book him/there.*

Conversely, some nonconstituents can be replaced by a proform. In example (8), the discontinuous phrase *two pies . . . eat* is replaced by *do it*, and in example (9), the antecedents of *they* are the separate phrases *Chris* and *David*:

(8) a. *Chris can eat one pie, but <u>two pies</u> he won't be able to <u>eat</u>.*

b. *Yes, he will be able to <u>do it</u>.*

(9) a. *<u>Chris</u> ran into <u>David</u> yesterday.*

b. *<u>They</u> decided to see a movie.*

Likewise, test (iv) is not fully reliable. While sentence fragments usually involve constituents, there are constituents that cannot appear as sentence fragments (10b), and non-constituents that can (10c):

(10) a. Q: *What has Chris written?*
A: *A best-selling novel.*

b. Q: *What has Chris done?*
A: **Has written a best-selling novel.*

c. Q: *Who did you see?*
A: *Chris yesterday, and David today.*

Although none of these tests are fully successful (as noted by Radford himself), some prove to be distinctly less useful than others. This attests to the difficulty of formulating unequivocal criteria for determining constituent structure units.

2. EVIDENCE FOR CONSTITUENT STRUCTURE

Criteria for phrase structure constituency in LFG appeal to the surface syntactic properties of utterances, not to semantic intuitions or facts about abstract functional syntactic structure. Since these surface properties vary from language to language, the tests discussed below make reference to properties of particular languages, and may not be applicable to every language. This is just what we would expect, since surface form and organization vary from language to language, while the more abstract functional structure is more uniform.

VERB-SECOND: Certain syntactic generalizations refer specifically to phrase structure constituents. For instance, in some languages, the position of the verb provides a test for constituency: the verb appears in second position in the sentence, after the first constituent. German is such a language; in German the sequence of words directly preceding the verb in a main clause must be a single constituent (leaving aside certain rare and clearly identifiable exceptions, cf. Zaenen and Kaplan 2002):

(11) *[Dem Mädchen] schien Hans das Buch zu geben.*
the.DAT girl seem.PST Hans the.ACC book to give.INF
'Hans seemed to give the girl the book.'

This argument can be repeated for many other verb-second languages, at least for the majority of data: Kroeger (1993) discusses verb-second phenomena in Germanic languages and in Tagalog; Zaenen and Kaplan (2002) and Cook and Payne (2006) discuss the German data in more detail; and Simpson (1991, 2007) discusses similar phenomena in Warlpiri.

QUESTION FORMATION: A similar argument for constituency comes from the English constituent question construction. Zwicky (1990) observes that in English, only a single displaced constituent can appear in clause-initial position:

(12) a. *[Which people from California] did you introduce to Tracy?*

b. **[Which people from California] [to Tracy] did you introduce?*

c. *[To how many of your friends] did you introduce people from California?*

d. **[People from California] [to how many of your friends] did you introduce?*

DISTRIBUTION OF ADVERBS: It is also possible to determine the presence and distribution of phrases of a particular type. Kaplan and Zaenen (1989b), following work by Þráinsson (1986), discuss the distribution of adverbs in Icelandic; Sells (1998, 2001b, 2005) builds on their work, analyzing Icelandic constituent structure in more detail. In an Icelandic sentence containing an auxiliary or modal verb such as *mun* 'will', an adverb like *sjaldan* 'seldom' has a restricted distribution:

(13) a. *Hann mun sjaldan stinga smjörinu í vasann.*
he will seldom put butter.DEF in pocket.DEF
'He will seldom put the butter in the pocket.'

b. **Hann mun stinga sjaldan smjörinu í vasann.*
he will put seldom butter.DEF in pocket.DEF

c. **Hann mun stinga smjörinu sjaldan í vasann.*
he will put butter.DEF seldom in pocket.DEF

d. *Hann mun stinga smjörinu í vasann sjaldan.*
he will put butter.DEF in pocket.DEF seldom

In sentences with no modal, the distribution of the adverb is more free:

(14) a. *Hann stingur sjaldan smjörinu í vasann.*
he puts seldom butter.DEF in pocket.DEF
'He seldom puts the butter in the pocket.'

b. *Hann stingur smjörinu sjaldan í vasann.*
he puts butter.DEF seldom in pocket.DEF

c. *Hann stingur smjörinu í vasann sjaldan.*
he puts butter.DEF in pocket.DEF seldom

Kaplan and Zaenen (1989b) propose that the distribution of the adverb depends on the presence or absence of a VP constituent: an adverb cannot appear as daughter of VP. Sentences with an auxiliary verb contain a VP constituent:

(15) *Hann mun [stinga smjörinu í vasann]*$_{\text{VP}}$.
he will put butter.DEF in pocket.DEF
'He will put the butter in the pocket.'

The adverb can appear as a daughter of S (or I′, in Sells's 2005 analysis), but not as a daughter of VP, accounting for the ungrammaticality of examples (13b,c). In contrast, sentences with no auxiliary verb have no VP, allowing for the wider range of possible adverb positions shown in (14).

PROSODY: A particularly interesting sort of evidence for phrase structure constituency arises from the interaction of constituent structure and prosody. King (1995, pages 129–130) notes that a Russian constituent may be signaled as in focus by falling intonation on its right edge; conversely, then, focus intonation may be viewed as indicating alignment with a right-edge phrasal boundary. Here, the feature +F represents this right-edge focus intonation, and the subscript FOCUS marks the focused constituent:[2]

(16) *kolxoz zakončil [uborku urožaja*$_{\text{+F}}$*].*
kolxoz finished harvest crop
'The *kolxoz* finished [the crop harvest]$_{\text{FOCUS}}$.'

A sentence is unambiguously a constituent, so as we would predict an entire sentence can be put in focus in this way (Junghanns and Zybatow 1997):

(17) Q: *What happened?*

A: *[sgorela ratuša*$_{\text{+F}}$*].*
burn.down town.hall

'[The town hall burned down]$_{\text{FOCUS}}$.'

See Zybatow and Mehlhorn (2000) for further discussion of focus intonation in Russian. While this example clearly demonstrates alignment between prosodic features such as intonation and syntactic groupings, we assume (with Lahiri and Plank 2010) that such alignment is not necessary and, indeed, is not often found; our approach to the formal relation between syntax and prosody will be presented in Chapter 11.

[2] King attributes example (16) to Krylova and Khavronina (1988, page 80).

Clitic placement: Zwicky (1990) proposes other "edge tests", tests that pick out the first or last word in a phrase. He argues that the distribution of the possessive clitic in an English possessive noun phrase is best described by referring to the right edge of the possessive phrase:

(18) *[my friend from Chicago]'s crazy ideas*

In this example, the possessor is *my friend from Chicago*, and the placement of the clitic *'s* shows that *my friend from Chicago* is a syntactic constituent (and not, for example, two separate constituents *my friend* and *from Chicago*). The syntax of the English possessive clitic is discussed in more detail by Payne (2009) and Lowe (2016b).

3. CONSTITUENT STRUCTURE ORGANIZATION AND RELATIONS

LFG assumes a strict version of the Lexical Integrity Principle (Chapter 4, Section 4): constituent structure positions cannot be filled only by affixes or (as Kroeger 1993, page 6 puts it) "disembodied morphological features." Every terminal node of the constituent structure tree corresponds to an individual word. There is no syntactic process of word assembly, though individual words can make complex syntactic contributions at the functional level (Chapter 4, Section 4). We discuss the place of morphology in the architecture of LFG in Chapter 12; in the following, we discuss the inventory of constituent structure categories and the organization of constituent structure.

3.1. Lexical Categories

We assume the following set of major lexical categories:

(19) Major lexical categories:

N(oun), P(reposition), V(erb), A(djective), Adv(erb)

Chomsky (1986) assumes that N, P, V, and A are major lexical categories; following Jackendoff (1977), we also assume that Adv is a major lexical category. These major lexical categories can head phrases of the corresponding category:

(20) a. NP: *the boy*
b. PP: *on the boat*
c. VP: *sail the boat*
d. AP: *very fearful of the storm*
e. AdvP: *quite fearfully*

In addition to these major lexical categories, some LFG work assumes a set of more crosslinguistically variable minor lexical categories. For example, Dalrymple (2001), Butt et al. (2002a), and Forst et al. (2010) assume the category Part, the category of English particles such as *up* in examples like (21):

(21) *David called Chris [up]*$_{\text{Part}}$.

Similarly, negative particles such as English *not* are sometimes assigned to a minor category Neg (see, for example, Sells 2000a on negation in Swedish). Another minor category is CL, which has been used to represent the category of clitics in some languages, for example in Romance languages (Grimshaw 1982a; Schwarze 2001a), in Bosnian/Croatian/Serbian (O'Connor 2002a; Bögel et al. 2010), in Sanskrit (Lowe 2011, 2014a), and in Pashto (Lowe 2016a). Sequences of CL clitics that appear as single unit (a 'clitic cluster') in a clause are sometimes grouped under a superordinate 'CCL' node (Bögel et al. 2010; Lowe 2011, 2014a; Lowe and Belyaev 2015).[3]

In contrast, some authors assume that there are no minor categories, and that the inventory of c-structure categories is fixed. For example, Toivonen (2003) and Bresnan et al. (2016) assume only four lexical categories, V, P, N and A (treating adverbs as part of A). Under such assumptions, apparent minor categories must be analyzed as subtypes of major categories. English particles of the sort seen in (21), for instance, are all homophonous with prepositions; it is therefore possible to treat them as belonging to the category P. The c-structure possibilities for English *not* partially match those of other English adverbs like *never*; *not* may therefore be analyzed as a member of the category Adv (as in 47 on page 116).

In fact, it is not necessary to propose a distinct minor c-structure category in order to account for different c-structure constraints on different subsets of a single c-structure category (for example, constraints on English particles as opposed to prepositions, or the negative *not* as opposed to other adverbs). The theory of non-projecting categories (Toivonen 2003), discussed in Section 3.4, permits a distinction between members of the same c-structure category that project full phrasal structure (like prepositions) and those that do not (like the particle in example 21). In addition, complex categories, discussed in Section 3.5, enable us to model differences in c-structure constraints between words of any category that differ in respect of some morphological or other feature.

In this work we do not make use of any minor categories; all the words that we analyze can be assigned to one of the five lexical categories stated in (19), or else to one of the functional categories introduced in Section 3.3 below.[4] In doing this, however, we make no claim as to the inventory of c-structure categories in Universal Grammar, and leave open the possibility that minor lexical categories may exist in some languages.

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[3]We use the term "clitic" here in purely syntactic terms; words that are treated as "clitics" on purely prosodic grounds (such as "prosodic deficiency") are not necessarily "clitics" in syntactic terms, and may in principle be part of any major lexical or functional c-structure category. See Lowe (2014a, 2016a) for further discussion of these issues.

[4]However, we do assume a non-X′-theoretic category Cnj for conjunctions such as *and*; we postpone discussion of conjunctions and coordinate structures to Chapter 16, where we provide a thorough discussion of the syntax and semantics of coordination.

3.2. X′ Theory

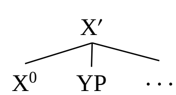
Constituent structure organization obeys the basic principles of *X′* (*X-bar* or $\bar{X}$) *theory* (Jackendoff 1977; Chomsky 1986): words appear as heads of phrases and may be associated with *specifier* and *complement* positions within the same phrase. X′ theory allows for general and abstract statements about the organization of phrases both crosslinguistically and within a language.

Using X as a variable over categories like N, V, or P, the basic principle of X′ theory is that a lexical or functional category X is related to *projections* of that phrase, often written as X′ (with one “bar level”), X″ (with two “bar levels”), and so on. Equivalently, we can speak of a lexical or functional category X *projecting* the phrases X′ and X″. For example, we can speak of V′ as a projection of the lexical category V, or of V as projecting the category V′. A lexical category such as V is sometimes written with a superscript 0 to indicate that it has zero “bar levels,” so that V^0 can be used as an alternative way of representing the lexical category V. However, Toivonen (2003) proposes a distinction between these two representations in her analysis of non-projecting words (see Section 3.4), according to which V and V^0 are not equivalent. We adopt Toivonen’s distinction in this work.

A standard assumption of X′ theory is that one of the projections of a category is a *maximal* phrase, and is thus usually written as XP. In other words, the category XP is the *maximal projection* of the category X. We adopt a simple two-level version of X′ theory in which X″ is the maximal phrase: thus, a phrase of category XP dominates a *nonmaximal* projection of category X′ which, in turn, dominates a word of category X^0, for any lexical or functional category X^0.

We further assume that a word of category X^0 may be sister to a series of *complement* phrases (YP. . .) and forms a constituent of category X′ whose phrasal head is X^0. The configurations in (22) and (23) illustrate the general X′-theoretic configuration we assume; languages vary as to where the head of the phrase appears in relation to the other daughters.

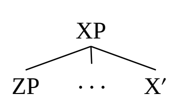
(22)



The X′ node may dominate any number of daughter phrases; we do not assume that constituent structure trees must be binary branching.

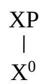
The X′ category may be sister to a series of *specifier* phrases (ZP. . .) and forms an XP phrasal constituent with X′ as its head:

(23)

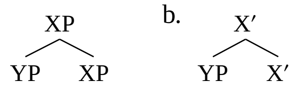


Some languages allow only a single specifier phrase; other languages (for example, languages like Russian, in which more than one question phrase can appear in sentence-initial specifier position) allow multiple specifiers.

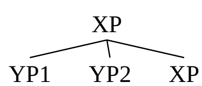
We also assume that an XP category can directly dominate a single X^0 category, as long as that is the only node it dominates. This permits us to simplify our representation by omitting intermediate X′ nodes that have no sisters and only one X^0 daughter:

(24)


Besides these X′-theoretic structures, other permissible phrase structure configurations have been proposed. It is generally assumed that it is possible to adjoin a maximal phrase to either a maximal (XP) or a nonmaximal (X′) projection, so-called "Chomsky-adjunction". In example (25a), YP is adjoined to XP, and in example (25b) YP is adjoined to X′.

(25) a. b.


Since we do not assume binary branching, it is possible to adjoin more than one phrase at a time. In example (26), YP1 and YP2 are adjoined to XP:

(26)


The adjoined phrase is often a modifier. Although the structures seen in examples (25) and (26) are the most widely accepted structures that involve adjunction, they are not the only types of adjunction that have been proposed. Another type, which we accept in this work, is the adjunction of nonmaximal, non-projecting categories to other categories, which we discuss in Section 3.4.

3.3. Functional Categories

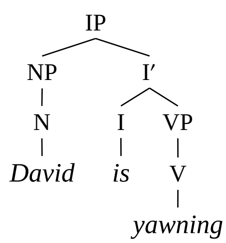
Besides the set of lexical categories described in Section 3.1, we assume a set of "functional" phrase structure categories; the terminology is standard but somewhat confusing, given the existence of functional structure (with a different sense of the word "functional") as a separate syntactic level in LFG. In this work, we assume the functional categories C, I, and D. Other functional categories have also been proposed in work within LFG, particularly in work on the structure of noun phrases, and we discuss these briefly in Section 3.3.4. Börjars et al. (1999) provide further discussion of functional categories and their motivation in LFG.

3.3.1. The Functional Category I

As Kroeger (1993) notes, the clausal syntax of a number of languages that are genetically unrelated and typologically quite different nevertheless organizes itself around a finite verbal element, either an auxiliary or a main verb, which appears in a specified (often second) position; languages as different as English, German, Warlpiri, and Tagalog all have a distinguished position in which a finite main or auxiliary verb appears. The position in which this element appears is called I (originally for INFL, i.e. *inflection*). The idea that the functional category I is the head of a finite clause was originally proposed by Falk (1984) in his LFG-based analysis of the English auxiliary system, and has since been incorporated, in different ways, into both transformational and nontransformational analyses of clausal structure (Chomsky 1986, 1993; Pollock 1989; Kroeger 1993; King 1995; Nordlinger 1998; Cinque 1999, 2003, 2004; Bresnan et al. 2016).

Languages can differ as to which lexical categories can fill the I position. In English, the tensed auxiliary appears in I, but nonauxiliary verbs may not appear there (see the discussion in Section 4.1.1 of this chapter):

(27) *David is yawning.*



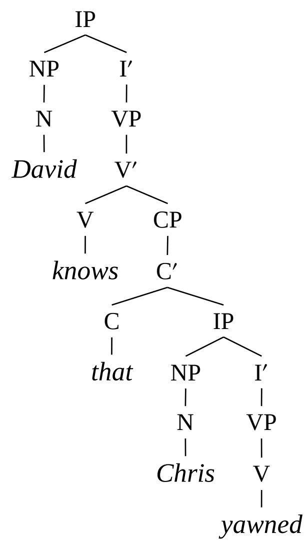
In other languages, such as Russian (King 1995), all finite verbs appear in I, as shown in example (44) on page 114.

3.3.2. The Functional Category C

The functional category C (for *complementizer*) was first proposed as the head of CP by Fassi-Fehri (1981), following unpublished work on English auxiliary inversion by Ken Hale. In English, as shown in example (28), and in many other languages, the C position can be filled by a complementizer like *that*.[5] Other elements may also appear in C position: like the functional category I, the C position may be filled by a verbal element, as in cases of subject-auxiliary inversion, seen in example (54) on page 118.

[5] As example (28) shows, we do not assume that a phrase like IP must dominate an I head; we discuss phrase structure optionality in Section 3.7 of this chapter.

(28) *David knows that Chris yawned.*

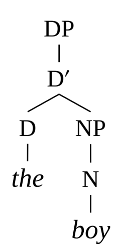


In other languages, the rules may differ. King (1995, Chapter 10) provides a thorough discussion of I and C in Russian, and Sells (1998, 2001b, 2005) discusses the structure of IP in Icelandic and Swedish.

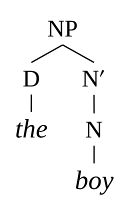
3.3.3. The Functional Category D

Following work by Brame (1982) and Abney (1987), many researchers have assumed that at least some instances of the category traditionally labeled "noun phrase" are more accurately treated as a determiner phrase or DP. According to this theory, the head of a phrase like *the boy* is the determiner *the*, as shown in example (29). This contrasts with the more traditional structure, shown in example (30), in which the noun is the head.

(29) *the boy* as a DP



(30) *the boy* as an NP

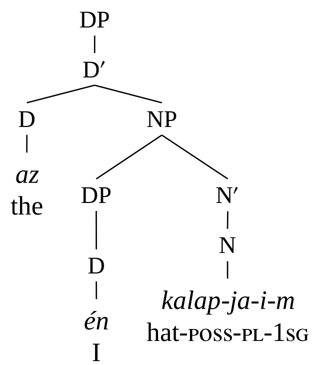


The projection DP was first assumed in an LFG context by Bresnan (1997, 2000) and by Sadler (1997), who presents an analysis of Welsh pronominal clitics as

Ds within a more complete DP analysis; Börjars (1998) discusses the internal structure of nominal phrases and the status of D in a range of languages.

DPs are now widely utilized in LFG work on many languages. The internal structure of nominal phrases is complex, however, varying considerably between languages. For example, Laczkó (2007) argues that Hungarian NPs can appear as a complement of D, as in (29), but that (unlike English) a (possessive) DP can appear as a specifier of NP, between the determiner and the noun. This is shown in (31), based on Laczkó's analysis of the Hungarian phrase *az én kalapjaim* 'my hats':[6]

(31) *az én kalap-ja-i-m*
the I hat-POSS-PL-1SG
'my hats'



In some languages there is little empirical motivation for a category DP, while in others there is much evidence. In this work we will not make detailed proposals concerning the internal syntactic structure of noun phrases; for simplicity, we will use the traditional category NP for noun phrases like *the boy* wherever possible (as in 30), using DP only where clearly motivated.

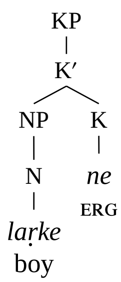
3.3.4. Other Functional Categories

Some analyses of noun phrases assume further levels of complexity and propose additional functional categories besides DP. We do not make use of any such additional categories in this work, but we provide here a brief overview of more complex analyses of noun phrases.

The category KP for phrases headed by a case marker K was prefigured in the seminal work of Fillmore (1968); in an LFG setting, Butt and King (2004b) propose that Hindi-Urdu has the category KP (see also Davison 1998 and Raza and Ahmed 2011). Butt and King provide the following c-structure for the ergatively casemarked Hindi-Urdu phrase *laṛke ne* 'boy ERG':

[6] Laczkó's (2007) proposal is actually somewhat more complicated, in that he assumes a complex structure below the N. For simplicity, we omit the details of this structure here.

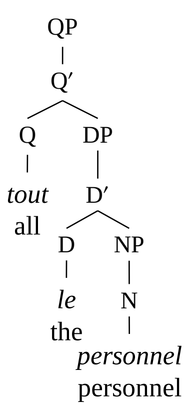
(32) *laṛke ne*
boy ERG



KPs are also assumed for Persian by Nemati (2010). In contrast, Spencer (2005a) argues that Hindi *ne* is a postposition, analyzed as a non-projecting P adjoined to NP, as shown in (39).

Another functional category sometimes assumed is QP, for phrases headed by a quantifier Q. Guo et al. (2007) assume a QP in their analysis of Chinese noun phrases with classifiers, and Spector (2009) assumes a QP for Hebrew nominal phrases. Wescoat (2007) assumes QP dominating DP for quantified noun phrases in French:

(33) *tout le personnel*
all the personnel

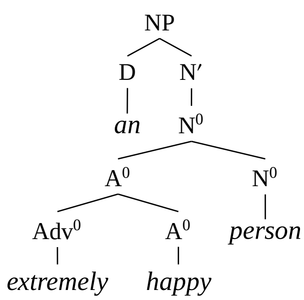


Occasionally other functional categories are proposed in order to account for the complex structure of noun phrases in certain languages. For example, Laczkó (2007) assumes a NumberP in Hungarian to account for the position of number words in nominal phrases, and Bögel et al. (2008) and Bögel and Butt (2013) propose an 'Ezafe Phrase', EzP, to account for the Urdu *ezafe*-construction, in which a particle *e* (the *ezafe*) connects a modifying noun or adjective with a preceding head NP. See Laczkó (1995) for an extensive discussion of the functional and phrasal syntax of noun phrases within the LFG framework.

3.4. Non-Projecting Categories

All the rules of constituent structure organization that we have discussed so far involve categories that project in a standard X′-theoretic way. There is also evidence, however, that some words can be "non-projecting". According to Sadler and Arnold (1994), lexical categories like A, which usually project full phrasal categories, can also appear as "small" or X^0 categories, adjoined to other X^0 categories. Sadler and Arnold call these adjoined structures "small" constructions, building on work by Poser (1992).[7] They argue that English prenominal adjectives participate in these constructions, proposing the following structure for the phrase *an extremely happy person*:

(34) *an extremely happy person* according to Sadler and Arnold (1994):



Treating *extremely happy* as a zero-level category A^0 explains why example (35a) is impossible while examples (35b) and (35c) are grammatical: English *happy* can take an IP complement (such as *to have finished*) only when it heads an AP, which it does in all contexts except prenominal position. That is, prenominal modifiers cannot be full AP phrases.[8]

(35) a. **an extremely happy to have finished person*

b. *She is extremely happy to have finished.*

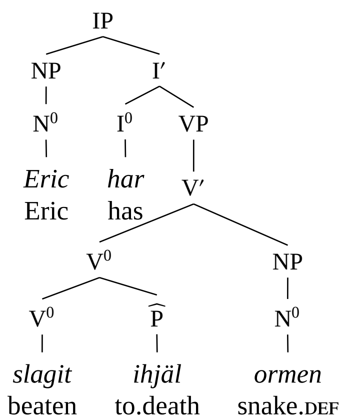
c. *She came in, extremely happy to have finished.*

[7] A "small" construction in Sadler and Arnold's sense is different from a "small clause" (Stowell 1981), a tenseless phrase consisting of a subject and a predicate.

[8] There is a highly restricted set of exceptions to this generalization, which are not accounted for by the structure proposed above. As noted by Arnold and Sadler (2013, page 65), a restricted set of prenominal adjectives can take phrasal complements, as long as those complements do not contain referential or quantificational nouns. Examples include *the eager to please student*, *a larger than average house*, and *a difficult to solve problem*. In some cases, these adjectival phrases have become conventionalized and are treated as units in the syntax, but this cannot explain all such examples. A more wide-ranging exception to the generalization made here is that almost any type of phrase can be used as a prenominal modifier, for example *I'm having one of those I'm-so-sick-of-this-bloody-job-that-I-could-scream days* (Arnold and Sadler 2013, page 65, ex. 93). The particular intonation required with such examples suggests that they require a separate account. Bresnan and Mchombo (1995, page 194) propose that phrases can be innovatively lexicalized, and thus used as if single words.

In subsequent work, Toivonen (2003) proposes that some words may be inherently non-projecting; that is, they never project full phrasal categories. Such non-projecting words may be of any lexical category, and they adjoin to an X^0 word just like Sadler and Arnold's "small" categories. Toivonen refers to projecting words as X^0 in the usual way, but distinguishes non-projecting words with the notation $\widehat{X}$ (following Asudeh 2002c). The plain label X is used by Toivonen as a cover term for X^0 or $\widehat{X}$. Toivonen (2003, page 2) proposes the structure in (36) for Swedish particle verbs (*ihjäl* 'to death' is a particle).

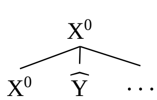
(36) *Eric har slagit ihjäl ormen*
Eric has beaten to.death snake.DEF
'Eric has beaten the snake to death.'



Non-projecting words are found in a variety of unrelated languages. Sells (1994) shows that non-projecting words play an important role in the phrasal syntax of Korean, and non-projecting words are also found in Zapotec (Broadwell 2007) and Welsh (Mittendorf and Sadler 2011). Lowe (2015d) shows that nonprojecting words can provide an insightful account of compounding forms in Sanskrit. It is important to note that this proposal somewhat changes the nature of the category X^0: it is not restricted purely to single words, but can also refer to phrases consisting of more than one word, such as *extremely happy* in (34) or *slagit ihjäl* in (36). We adopt Toivonen's terminology and notation in this work.

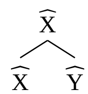
Toivonen (2003) assumes that multiple $\widehat{X}$s may adjoin to a single X^0, and permits adjunction by a non-projecting category only to a projecting X^0 category:

(37)



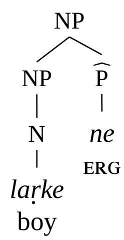
Arnold and Sadler (2013) argue that non-projecting categories must also be permitted to adjoin to other non-projecting categories, as in the following configuration:

(38)



Spencer (2005a) argues that non-projecting categories may also adjoin to full phrasal categories; for example, he proposes that Hindi-Urdu postpositions are non-projecting $\widehat{\mathrm{P}}$s that adjoin to NP. His proposal implies the following analysis of the Hindi-Urdu phrase *laṛke ne* ‘boy ERG’ (for a contrasting analysis, compare example 32 on page 109):

(39) *laṛke ne*
boy ERG



We do not assume that there are any necessary restrictions on what categories non-projecting words may adjoin to.

From now on in this book, we use X as an abbreviation for X^0; non-projecting words are always referred to as $\widehat{\mathrm{X}}$.

3.5. Complex Categories

In any language, the inventory of forms that make up a particular c-structure category includes sets of forms with differing features. For example, in English both singular nouns and plural nouns are part of the same c-structure category N. Likewise, in English both finite verb forms and non-finite verb forms such as participles and infinitives are part of the same c-structure category V. While these c-structure categories permit us to make valid generalizations over the varied sets of forms they contain, it is sometimes useful to be able to make c-structure generalizations over only some members of a category. For example, some c-structure rules may apply not to all members of the category V, but only to those that are finite.

Complex c-structure categories provide a way of stating fine-grained constraints on categories through the use of c-structure *parameters*. For example, Frank and Zaenen (2002) propose that the VP category in French is parametrized for finiteness, and that the V category is parametrized for finiteness and verb type. The parameters of a category are written in square brackets after the category label: for example, VP[fin] is a VP with the parameter for finiteness set to fin, for finite. Frank and Zaenen (2002) assume a non-standard, flat structure for the French VP, providing the following sample configuration:

(40) Frank and Zaenen (2002, page 51):

VP[fin]

V[aux,fin] (V[aux,part]) V[main,part]

In this configuration, a finite VP (VP[fin]) dominates a finite verbal auxiliary (V[aux,fin]), an optional participial auxiliary (V[aux,part]), and a participial main verb (V[main,part]). On this view, the category of a verb must include the parameter specifications appropriate for its form. For example, the French finite auxiliary verb *est* has the c-structure category V[aux,fin]:

(41) *est*: V[aux,fin]

As we show in Chapter 5, Section 1.4, this pattern can be generalized to other values for finiteness by allowing the parameters of the rule to be instantiated in different ways, placing fine-grained constraints on how different subtypes of categories can be realized.

Falk (2003, 2008) builds on Frank and Zaenen's proposals in his analysis of the English auxiliary system. Complex categories are also discussed by Kuhn (1999) and Crouch et al. (2008).

3.6. Categorial Inventory

The inventory of phrasal categories may vary from language to language; we do not assume that a phrasal category exists in a language unless there is direct evidence for it. Criteria for determining the presence of a phrasal category differ according to whether the phrase is a projection of a lexical or a functional category.

The existence of a projection of a lexical category in a language must in the first instance be motivated by the presence in the language of some word of that lexical category (King 1995). That is, for example, the existence of a VP phrase in the constituent structure of a language implies that there are lexical items of category V in that language. If a lexical category does not appear in a language, its corresponding phrasal projection does not appear either.

Even when there is evidence for a lexical category in a language, the corresponding phrasal category may in some cases not appear. For instance, although some Warlpiri words are of category V, Simpson (1991) shows that there is strong evidence against the existence of VP in Warlpiri. Any single XP constituent may appear before the Warlpiri auxiliary:

(42) *[watiya-rlu wiri-ngki] ji paka-rnu*
stick-ERG big-ERG AUX hit-PST
'He hit me with a big stick.'

As Simpson points out, if the V formed a VP constituent with the object phrase, we would expect example (43) to be grammatical; in fact, however, it is not grammatical:

(43) *[*wawirri*] [*panti-rni*] *ka ngarrka-ngku*
kangaroo.ABS spear-NPST AUX man-ERG
'The man speared the kangaroo.'

Simpson (1991) presents a number of other arguments to show that Warlpiri has no VP, although it does have a V′ constituent.

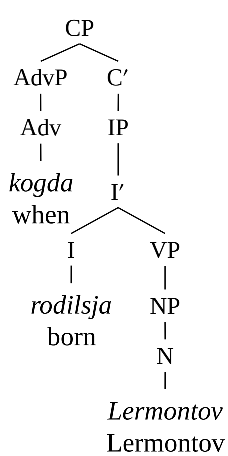
In the case of functional categories, evidence is often less directly available; here too, however, categories are only presumed to exist if they are motivated by direct evidence. For instance, Laczkó (2016) argues that there is no evidence in Hungarian for the existence of the category IP or I.

3.7. Optionality of Constituent Structure Positions

In the theory of constituent structure proposed by Chomsky (1986), heads of phrases are obligatorily present, complements (sisters to X categories) are present according to predicate valence, and specifier positions (sisters to X′ categories) are optional. In contrast to this view, we do not assume that any phrase structure position is crosslinguistically obligatory, including the head and complements. As discussed in Chapter 2, Section 3, subcategorization requirements are most appropriately specified at the level of f-structure, and so there is no necessity for predicate valence to be reflected in c-structure representation. And since heads can appear outside their phrases (cases of so-called "head movement": see Chapter 4, Section 3.1 and Zaenen and Kaplan 1995, King 1995, and Nordlinger 1998), the position of the head must also be optional.

The following Russian example illustrates the optionality of a number of constituents (King 1995, page 172):

(44) *kogda rodilsja Lermontov?*
when born Lermontov
'When was Lermontov born?'



As the tree in (44) shows, there is no specifier position of IP if there is no topicalized or focused non-interrogative constituent (King 1995, page 172). Additionally, the tree illustrates "headless" constructions; the VP constituent does not dominate a V node, since the tensed verb in Russian appears in I; also, the CP does not dominate a C. For more discussion of phrasal categories that do not contain a lexical head, see Zaenen and Kaplan (1995).

Some LFG researchers, including Kroeger (1993), King (1995), and Bresnan et al. (2016), make the strong claim that all constituent structure positions in all languages are optional. However, Snijders (2012, 2015) demonstrates that, while optionality is a strong crosslinguistic tendency, it is not without exceptions, and certain positions are obligatory in certain languages. In particular, Snijders discusses constraints on optionality in Latin, showing that the NP complement in a PP is obligatory, even though all elements of an NP are themselves optional within the NP. That is, some portion of the NP complement, not necessarily including the head, must appear adjacent to the P.

4. CLAUSAL ORGANIZATION

4.1. IP and CP

In many languages, IP corresponds to a sentence, and CP corresponds to what was called S′ in early transformationalist literature, a sentence with a complementizer or a displaced phrase in sentence-initial position. Here we examine some basic structures in English and draw some contrasts with constituent structures in other languages. Of course, no conclusions for the structure of other languages should be drawn from the organization of English: LFG does not claim that the phrasal organization of every language is the same. Since there is a great deal of crosslinguistic typological variation in constituent structure organization, what is true for English cannot be assumed to be true in other languages. We must carefully examine each language on its own terms to determine its phrasal structure and organization.

4.1.1. The IP Phrase

In English, the tensed auxiliary verb appears in I, and the rest of the verb complex appears inside the VP. Evidence that the English VP forms a constituent comes from the fact that, like other constituents, it can be preposed for information structure reasons:

(45) a. *David wanted to win the prize, and [win the prize] he will.*

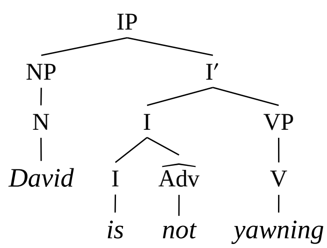
b. . . . *there is no greater deed than to die for Iran. And [dying] they are,* . . . (from Ward 1990)

It is not possible to prepose only the auxiliary and verb, since they do not form a constituent:

(46) **David wanted to win the prize, and [will win] he the prize.*

Since the sentential negation morpheme *not* must be preceded by a tensed auxiliary verb, we assume that it is a non-projecting adverb ($\widehat{\mathrm{Adv}}$) right-adjoined to the tensed verb in I:

(47) *David is not yawning.*

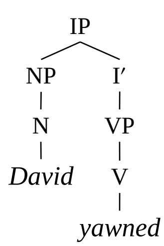


It is not possible in (modern) English for the negation marker to follow a nonauxiliary verb (in contrast with French; see Pollock 1989):

(48) **David yawned not.*

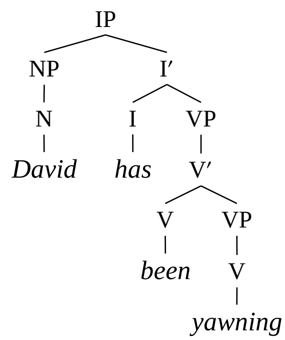
Thus, in English only a tensed auxiliary verb can appear in I, and main verbs, whether tensed or nontensed, appear inside the VP. When there is no auxiliary verb, the I position is not filled and the IP is ‘headless’:

(49) *David yawned.*



Nontensed auxiliaries appear in V and not the I position in English:

(50) *David has been yawning.*



In contrast to English, only nontensed verbs appear within the VP in Russian. King (1995) provides several pieces of evidence supporting this claim. A VP constituent that contains a nontensed verb can be scrambled to a higher clause in colloquial Russian:[9]

(51) *mne [otpustit' Katju odnu] kažetsja, čto bylo by bezumiem.*
me let.go.INF Katja alone seem that would be insane
'It seems to me that it would be insane to allow Katja to go alone.'

A similar construction involving a tensed verb is not grammatical, since the tensed verb is not a constituent of VP:

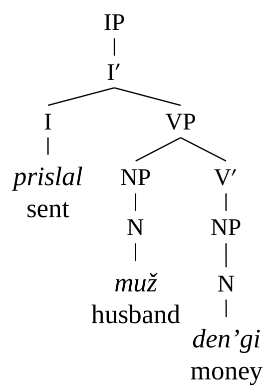
(52) **ja [pošel v školu] skazal, (čto) on.*
I went to school said that he
'I said that he had gone to school.'

King concludes from this and other evidence, based on coordination and the distribution of the negative marker *ne*, that nontensed verbs are of category V in Russian. In contrast, all tensed verbs in Russian appear in I position (King 1995), as shown in example (53):

(53) *prislal muž den'gi.*
sent husband money

[9] King attributes examples (51)–(52) to Yadroff (1992).

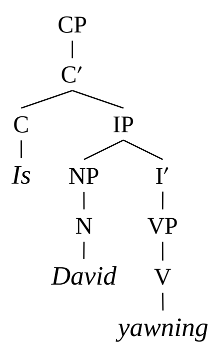
‘My husband sent (me) money.’



4.1.2. The CP Phrase

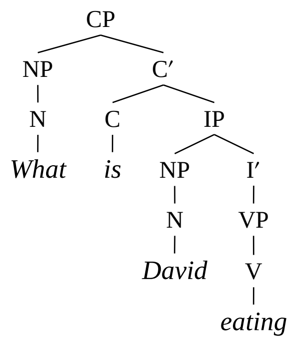
In English questions, the auxiliary verb appears in C:

(54) *Is David yawning?*



Thus, a tensed English auxiliary appears in C in constructions involving subject-auxiliary inversion, and in I otherwise. Constraints involving the f-structure of constructions requiring or forbidding subject-auxiliary inversion ensure that the auxiliary appears in the proper position in each instance. The question word appears in the specifier position of CP in English, with the auxiliary verb in C (King 1995, Chapter 10):

(55) *What is David eating?*



Many languages are unlike English in configurational structure. We now examine some of this variability, and discuss how languages can vary within the limits imposed by X′ theory and the universally available mappings between c-structure and f-structure which we examine in Chapter 4.

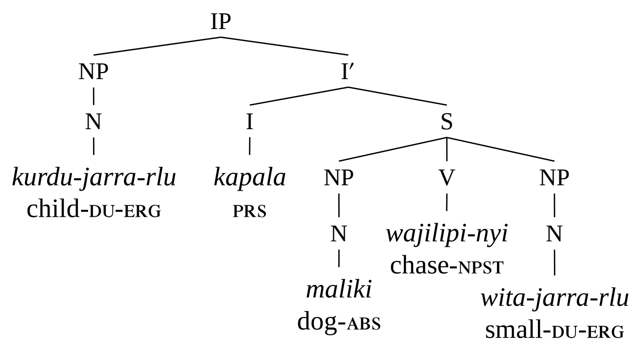
4.2. Exocentricity and Endocentricity

We have seen that the constituent structure of English abides by X′-theoretic principles: a head of category X can project a nonmaximal phrase X′ and a maximal phrase XP of the same category. Headed categories like XP and X′ are called *endocentric* (Bloomfield 1933), and the tendency for languages to make use of endocentric categories and for grammatical functions to be determined by configurational syntactic relations is what Bresnan et al. (2016) call the *principle of endocentricity*.

In contrast, some languages allow an *exocentric* category, one that has no head: the category S (Bresnan 1982a; Kroeger 1993; Austin and Bresnan 1996; Nordlinger 1998). According to Bresnan et al. (2016), languages making use of the category S are *lexocentric*, meaning that syntactic functions are determined by features associated with words rather than by configurational structure. S is a constituent structure category that can contain a predicate together with any or all of its arguments and modifiers, including the subject; for this reason, Austin and Bresnan (1996) call languages with the category S, including Tagalog, Hungarian, Malayalam, and Warlpiri, "internal subject" languages. As an exocentric category, the category S can dominate a series of either lexical or phrasal constituents. Some authors permit the category S even in thoroughly endocentric languages such as English (Bresnan et al. 2016), but we restrict its use to those languages which show clear evidence for exocentric structure.

According to Austin and Bresnan (1996), the phrase structure of a simple Warlpiri sentence is as follows:[10]

(56) *kurdu-jarra-rlu kapala maliki wajilipi-nyi wita-jarra-rlu*
child-DU-ERG PRS dog.ABS chase-NPST small-DU-ERG
'The two small children are chasing the dog.'



The Warlpiri I′ consists of an I, in which the clitic auxiliary appears, and an S complement. A phrasal constituent of any category appears as the specifier daughter of IP; in (56), a noun phrase fills the specifier of IP. Importantly, there are no syntactic constraints on the order of words in the sentence, so long as the auxiliary appears in second position (Simpson 1991; Austin and Bresnan 1996).[11] The daughters of S can in principle appear in any order, and no element obligatorily appears as daughter of S, since any phrasal constituent can appear in the specifier of IP position.

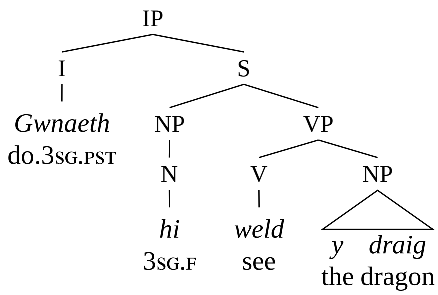
In Chapter 4, we discuss the close correlation between specifier and complement constituent structure positions as defined by X′ theory and the grammatical functions of the phrases that appear in those positions. For example, in many languages the subject must appear in the specifier position of IP. In contrast, the relation between constituent structure positions dominated by S and their abstract functional role does not obey the same X′-theoretic constraints. Thus, in languages which, like Warlpiri, make use of the exocentric category S, constituent structure position is often not an indicator of grammatical function. Instead, grammatical functions are often marked morphologically, by means of case endings, with a concomitant tendency to freer word order.

The category S has also been proposed for languages that have relatively fixed word order. Sadler (1997) proposes the following clausal structure for Welsh, a VSO language:

[10] Legate (2002), Laughren (2002) and Simpson (2007) show that many Warlpiri sentences are in fact more complicated than this, insofar as various projections exist above the IP, but this does not affect the phrasal configuration below the IP.

[11] The order of words is highly constrained according to other, namely information structural, factors (Simpson 2007).

(57) *Gwnaeth hi weld y draig.*
do.3SG.PST 3SG.F see the dragon
'She saw the dragon.'



On Sadler's analysis, the tensed verb in Welsh is always of category I. The complement of I is S; S dominates the subject NP and a predicate XP, which may be a VP, as in example (57), or a maximal phrase of different category, for example NP or AP in copular constructions (on copular constructions, see Chapter 5, Section 4.5). Similar clausal structures are assumed by Kroeger (1993) and Asudeh (2012, pages 157–163) for Irish, and by Falk (2001b, pages 51–52) for Hebrew.

A further functional category E (for Expression or External-Topic), originally proposed by Banfield (1973), has been proposed in analyses of left-dislocated phrases, such as external topics that are intonationally and syntactically separated from the rest of the clause. In (58), *David* is an external topic (and not a vocative), and the syntactic separation of *David* from the rest of the sentence is clear from the fact that a resumptive pronoun appears and a gap is not allowed.

(58) *(As for) David, what did he/*∅ do today?*

Within LFG, the category E is used by King (1995), building on work by Aissen (1992), in her analysis of Russian c-structure, and also by Jaeger and Gerassimova (2002) for Bulgarian, Simpson (2007) for Warlpiri, and Lowe (2012) for Sanskrit. However it is often possible to account for external topics and similarly positioned phrases by assuming adjunction to a clausal node, without recourse to an additional phrase-structure category. In the sentence above, for example, the NP *David* may be analyzed as adjoined to CP. We have no need for E in this work, and so will make no use of it.

5. THE S-STRING

As we have seen, constituent structure represents hierarchical phrasal syntactic relations between words. This hierarchy is related, of course, to the linear order of those words, but is separate from it. So, in example (57), the word *hi* '3SG.F' is more closely related to *draig* 'dragon' than to *gwnaeth* 'do.3SG.PST' in hierarchical terms (since both *hi* and *draig* are part of the same S constituent), even though in linear terms *hi* is adjacent to *gwnaeth* but three words distant from *draig*. However, some syntactic phenomena appear to make reference to linear relations rather than, or in addition to, hierarchical ones.

In the architecture proposed by Kaplan (1987, 1995), constituent structure is projected from the string, the linearly ordered sequence of words that we are familiar with when we speak or write anything, one word after another. Dalrymple and Mycock (2011) propose a more detailed model of the string, whereby it consists of two parts or "sides": the *s-string*, representing the string of syntactic units, and the *p-string*, representing the string of phonological units that correspond to the s-string. The p-string, and the architectural assumptions underlying this conception of the string, is discussed in more detail in Chapter 11; for present purposes only the s-string is relevant, as a level of syntactic representation encoding linear order between syntactic units. We can therefore represent the s-string for example (57) as follows.

(59) *gwnaeth hi weld y draig*

This may appear trivial, but it is important for several reasons. Lowe (2016b) adapts the theory of 'Lexical Sharing' developed by Wescoat (2002, 2005, 2007, 2009), according to which it is possible for single items in the s-string (Wescoat's 'linear structure') to be associated with two terminal nodes in the c-structure. In French, for example, some sequences of preposition followed by determiner are, unremarkably, sequences of two separate words, but certain other sequences of preposition followed by determiner are single words:

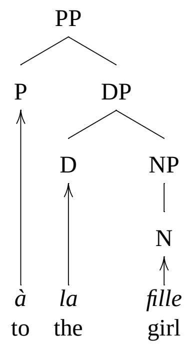
(60) a. *à la fille*
to the girl

b. **à le garçon*
to the boy

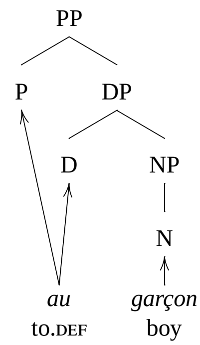
c. *au garçon*
to.the boy

As Wescoat points out, forms like *au* cannot be derived by regular phonological rules from two-word sequences; there are no synchronic phonological processes in French that would produce *au* ([o]) from *à le* ([a lə]). Lexical Sharing permits a consistent representation of all preposition-determiner sequences in French (we use the formulation of Lowe 2016b, rather than that of Wescoat).

(61) *à la fille*
to the girl
'to the girl'



(62) *au garçon*
to.the boy
'to the boy'



The arrows between the s-string and the c-structure represent the fact that these are not constituency relations, but a "projection" from one syntactic level (the s-string, encoding linear order) to another (the c-structure, encoding hierarchical relations). This is compatible with Carnie's (2012b, page 93) observation that the relation between words (s-string units) and the c-structure is different from the relation between c-structure nodes.[12] The s-string and its relation to c-structure is discussed in more detail in Chapter 11.

Lexical Sharing is also assumed by Broadwell (2007, 2008) in his analyses of Zapotec and Turkish, by Alsina (2010) in his analysis of Catalan, by Belyaev (2014) in his analysis of Ossetic, and by Lowe (2015d) in his analysis of Sanskrit compounds. Mismatches between the s-string and c-structure may also be relevant to the phenomenon of "prosodic inversion," examined by Halpern (1995) and, in an LFG setting, by Kroeger (1993), Newman (1996), Austin and Bresnan (1996), Nordlinger (1998), Bögel et al. (2010), Bögel (2010) and Lowe (2011). Lowe (2016a), building on a suggestion by Dalrymple and Mycock (2011), argues that the observed distinction between what Halpern calls "surface order" (the order of the words in a sentence) and "syntactic order" (their order in the constituent structure tree) is best captured as a difference in the order of items between the s-string and c-structure, rather than a distinction between syntax and prosody, as is assumed in many previous works. Other authors who investigate different aspects and uses of the s-string include Mycock (2006) and Asudeh (2006, 2009).

Like other linguistic levels, the s-string is subject to wellformedness constraints, which may differ on a language-by-language basis. These constraints will be discussed in more detail in Chapter 6, Section 11 and Chapter 11. In Chapter 11, Section 4.1 we will see that a considerably more refined treatment of the string enables us to analyze interactions between syntax, prosody, and

[12] We do not adopt Carnie's convention of representing this difference by omitting the line between the s-string unit and the c-structure.

other aspects of the linguistic structure of an utterance. For certain phenomena, then, the s-string, as a separate syntactic component, is an essential component of analysis. Nevertheless, in the vast majority of cases, as in examples (57) and (61), the relation between the s-string and c-structure is straightforward. In the following chapters we explicitly represent the s-string as separate from the c-structure only where necessary; otherwise we assume the separate s-string and the arrows connecting s-string units to terminal c-structure nodes only implicitly, and we maintain the simpler representation (which does not include arrows) as illustrated in the previous sections of this chapter.

6. FURTHER READING AND RELATED ISSUES

Bresnan et al. (2016, Chapter 6) provide an alternative theory of constituent structure categories involving a featural decomposition of category types that define lexical and functional categories, treating natural classes of categories in terms of a set of basic features “predicative”, “transitive”, and “functional”. Marcotte (2014) and Dalrymple (2017) also explore the decomposition of c-structure categories into sets of primitive features. Otoguro (2015) discusses the morphological basis for the classification of verbs as V or I. Marcotte (2014) and Lovestrand and Lowe (2017) explore alternative formalizations of phrase structure which preserve many of the intuitions of X′ theory (Section 3.2) but require fewer non-branching nodes.

Besides the work we have discussed so far, the following is of note on constituent structure issues in different languages: Börjars et al. (2003) on Swedish; Berman (2003) on German; Sells (2005) on Icelandic; King (2005) on the treatment of clitics; Dipper (2005) on German quantifiers; Bresnan (1997), Seiss (2008), and Bresnan and Mugane (2006) on the treatment of so-called ‘mixed categories’ such as the English gerund; Lødrup (2011b) on Norwegian possessive pronouns; and Cavar and Seiss (2011) on Bosnian/Croatian/Serbian clitics.

4

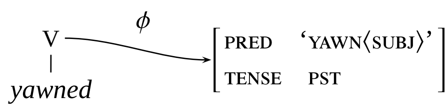
SYNTACTIC CORRESPONDENCES

LFG hypothesizes that constituent structure and functional structure are mutually constraining structures and that the relation between these structures is governed by constraints associated with words and phrasal configurations. We turn now to an investigation of the relation between these two facets of linguistic structure: in this chapter, we explore universally valid generalizations regarding the correlation between phrasal positions and grammatical functions.

Section 1 of this chapter discusses the formal representation of the relation between c-structure and f-structure. Section 2 explores the relation between c-structure and f-structure: how c-structure phrases and their heads relate to f-structure, and the c-structure/f-structure realization of arguments and modifiers. Next, we examine apparent mismatches between units at c-structure and those at f-structure; Section 3 shows that these cases have a natural explanation within LFG. In Section 4, we discuss the *Lexical Integrity Principle*, the concept of wordhood, and the possibly complex contribution of words to functional structure, and in Section 5, we discuss the principle of *Economy of Expression*.

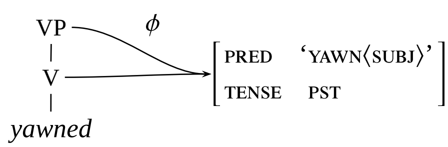
1. RELATING CONFIGURATIONAL AND FUNCTIONAL STRUCTURE

As aspects of a single complex linguistic structure, c-structure and f-structure are related to one another in a finely specified way: the pieces of the c-structure that constitute the subject are related to the f-structure for the SUBJ, for example. Formally, the relation between the two structures is given by a function[1] called ϕ that relates c-structure nodes to f-structures. Each c-structure node is related by this function to a particular f-structure, and since ϕ is a function, no c-structure node can be related to more than one f-structure. Pictorially, the ϕ function is represented by an arrow, which can be labeled ϕ, from the c-structure node to its corresponding f-structure:

(1)


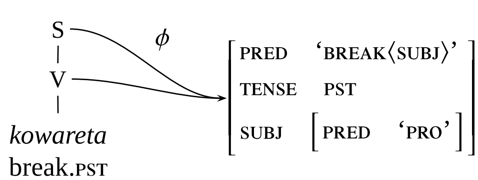
As this diagram shows, the word *yawned* is of category V, and the V node is associated with certain functional syntactic information: the f-structure corresponding to the V node has a PRED with value 'YAWN⟨SUBJ⟩', and the attribute TENSE with value PST.

Often, more than one c-structure node is related to the same f-structure. For instance, a phrase and its head correspond to the same f-structure:

(2)


There are also f-structures that are not related to any c-structure node. In Japanese (Kameyama 1985), a "pro-drop" language, the single word *kowareta* 'broke' can appear without an overt subject noun phrase. In such cases the SUBJ f-structure is interpreted pronominally, and does not correspond to any node in the c-structure:

(3) *koware-ta*
break-PST
'[It/Something] broke.'



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[1]Chapter 2, Footnote 19 provides a definition of the term "function."

2. REGULARITIES IN THE C-STRUCTURE/F-STRUCTURE MAPPING

The mapping function from c-structure to f-structure obeys universal principles: a phrase and its head always correspond to the same f-structure, for example, and phrase structure complements play particular grammatical roles. In this section, we examine these regularities and how they constrain the relation between the two syntactic structures of LFG.

2.1. Heads

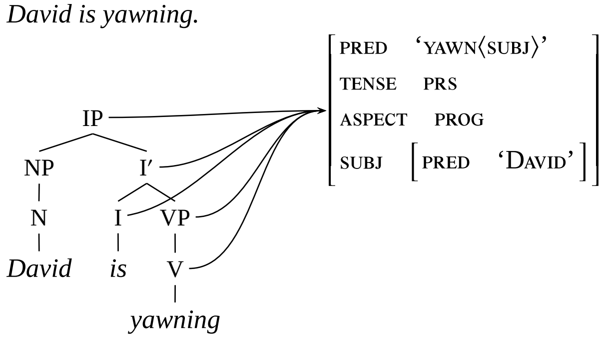
The functional properties and requirements of the head of a phrase are inherited by its phrasal projections and become the functional properties and requirements of the phrases projected by the head. This means that a constituent structure head and the phrases it projects are mapped onto the same f-structure, as shown in (2). This condition was originally proposed by Bresnan (1982a, page 296) and discussed by Zaenen (1983), who calls it the *Head Convention*.

2.2. Complements

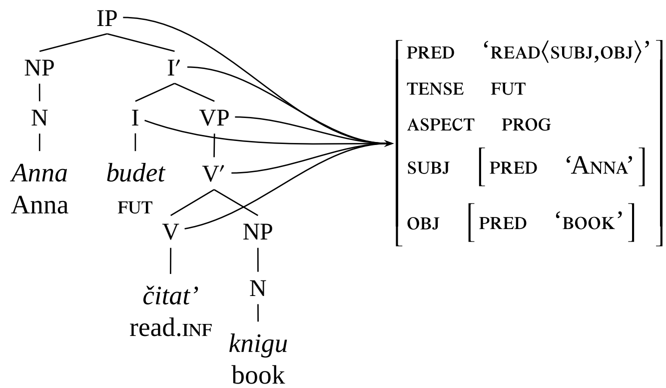
2.2.1. Complements of Functional Categories

Recall that complement positions are sisters to the head of a phrase. Complements of functional categories are f-structure co-heads (Kroeger 1993; King 1995; Bresnan et al. 2016), meaning that a functional category shares its functional properties with its complement. For example, the English IP shares the functional syntactic properties of its VP complement. Thus, an f-structure can be associated with two different c-structure heads, one a functional category and the other a lexical category, as shown in the English example in (4) and the Russian example in (5) (from King 1995, page 227):

(4) *David is yawning.*



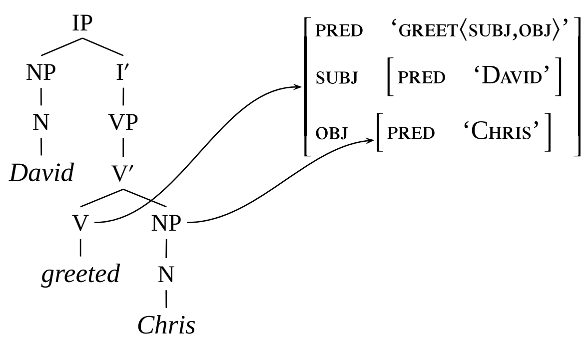
(5) *Anna budet čitat' knigu.*
Anna FUT read.INF book
'Anna will be reading a book.'



2.2.2. Complements of Lexical Categories

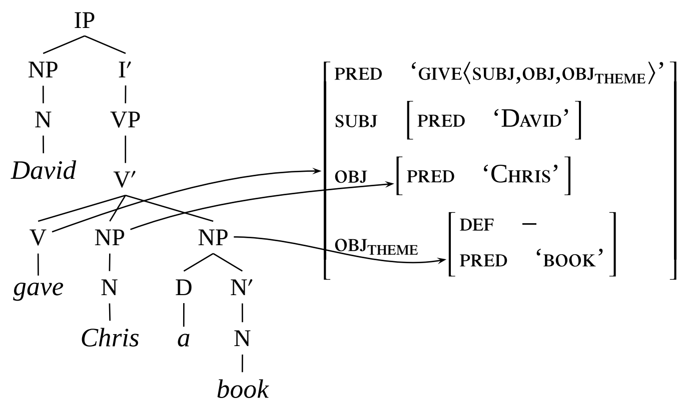
Bresnan et al. (2016) claim that complements of lexical categories can bear any of the governable grammatical functions except for SUBJ. In the following English example, the OBJ phrase *Chris* is a sister to V:

(6) *David greeted Chris.*



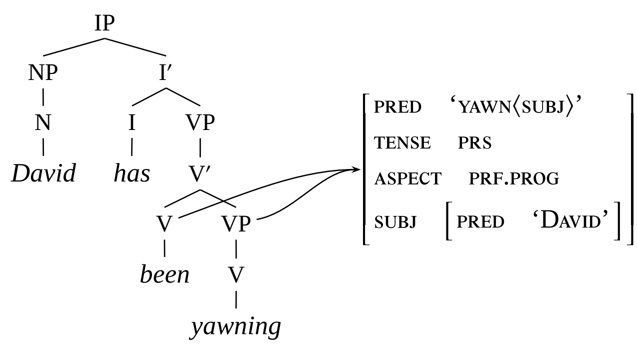
Of course, more than one complement may appear; in example (7), the first complement bears the OBJ role, and the second complement is $\text{OBJ}_{\text{THEME}}$:

(7) *David gave Chris a book.*



The complement of a lexical category can also correspond to the same f-structure as the head of the phrase, as in the case of English nonfinite auxiliaries and their complement VPs (Bresnan et al. 2016, Chapter 6):

(8) *David has been yawning.*



Falk (1984, 2001b), Butt et al. (1996b), Sadler (1998), and Bresnan et al. (2016) provide further discussion of the English auxiliary system.

According to Laczkó (2014a), Hungarian is an exception to Bresnan et al.'s (2016) claim that only nonsubject arguments can appear in complement positions. In Hungarian, a subject can appear postverbally, and its position is not fixed; it can appear in any order with other postverbal arguments.

(9) a. *Szereti János Mari-t.*
loves John.NOM Mary-ACC
'John loves Mary.'

b. *Szereti Mari-t János.*
loves Mary-ACC John.NOM
'John loves Mary.'

As É. Kiss (2002) and others have observed, the different orders of postverbal arguments in Hungarian are essentially equivalent in terms of interpretation. Laczkó (2014a) proposes that the subject can appear within V′ in Hungarian, as a complement of the lexical category V, in the same position as postverbal complements bearing other governable grammatical functions.

Since LFG does not define subcategorization properties of predicates in c-structure terms, the arguments of a predicate may but are not required to appear in complement positions. They may, for example, appear in the specifier position of some projection, and are linked to their within-clause function by means of purely functional specifications. Resolution of long-distance dependencies is discussed briefly in the next section, and in more detail in Chapter 17.

2.3. Specifiers

Recall that the specifier of a constituent structure phrase is the daughter of XP and sister to X′. We propose that specifier positions are filled by phrases that are prominent either syntactically or in information-structural terms (compare Bresnan et al.'s 'Clause-prominence of DFs' principle: Bresnan et al. 2016, page 209). Syntactically prominent phrases that can appear in specifier positions in the clause are those bearing either the function SUBJ or the overlay function DIS heading a long-distance dependency (see Chapter 2, Section 1.11). Information-structurally prominent phrases can also appear in specifier position; if they are not syntactically prominent, they may bear any grammatical function within the local clause. The table in (10) shows the permitted grammatical and information structure roles of phrases appearing in specifier positions (see Snijders 2015 for further discussion):

(10) For phrases in specifier position within the clause:

Grammatical role	Syntactically prominent?	Prominent at information structure?
SUBJ in the local clause	yes	yes or no
any grammatical function in the local clause	no	yes (topic or focus)
DIS, related to a potentially nonlocal grammatical function	yes	yes (topic or focus)

In this, our position differs from some other LFG work (Dalrymple 2001; Bresnan et al. 2016), which assumes that specifier positions are filled by phrases bearing particular f-structure roles: SUBJ, TOPIC, or FOCUS. Following Asudeh (2012), we assume that TOPIC and FOCUS are information structure roles, and are not represented at f-structure. Rather, phrases that play the role of topic or focus at information structure can appear in a specifier position with no necessary restriction on the grammatical function that these phrases can bear, or in other positions within the clause. See Chapter 10 for more discussion of information structure in LFG's projection architecture, including a historical overview of the treatment of information structure roles in LFG.

2.3.1. Syntactically Prominent Specifiers

A phrase in specifier position that is syntactically prominent bears either the SUBJ function in the same clause, or the overlay function DIS. If it bears the DIS function, there are two possibilities: it participates in an unbounded dependency and is identified with a (nonoverlay) grammatical function in the same clause or an embedded clause, as in (11a), or it is a dislocated constituent which is anaphorically related to a clause-internal (nonoverlay) grammatical function, as in (11b).

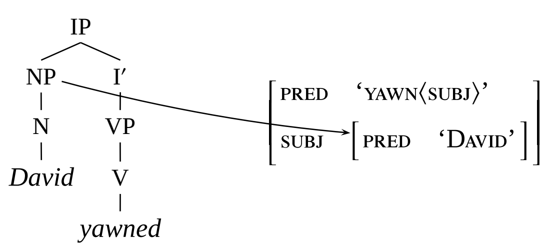
(11) a. *Chocolate, David loves* ___.

b. *Chocolate$_i$, David loves it$_i$.*

In examples like (11a), the within-clause function of a displaced phrase is specified by means of *functional uncertainty*; see Chapter 6, Section 1.2 for definition and discussion of functional uncertainty, and Chapter 17 for a more detailed discussion of long-distance dependencies. Examples like (11b) involve an anaphoric relation between the displaced phrase and a pronoun; see Chapter 14.

SUBJ IN SPECIFIER POSITION In English and many other languages, the specifier position of IP is associated with the SUBJ function:[2]

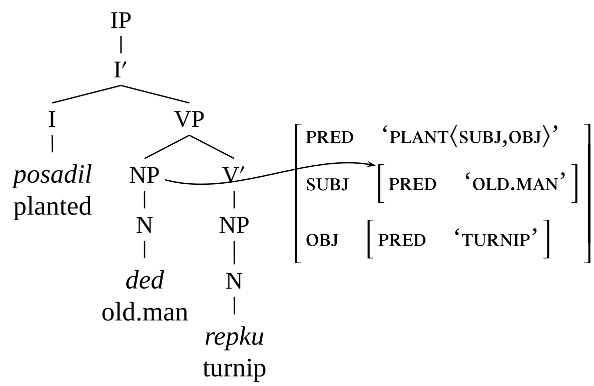
(12) *David yawned.*



King (1995) shows that only subjects can appear in the specifier position of VP in Russian:

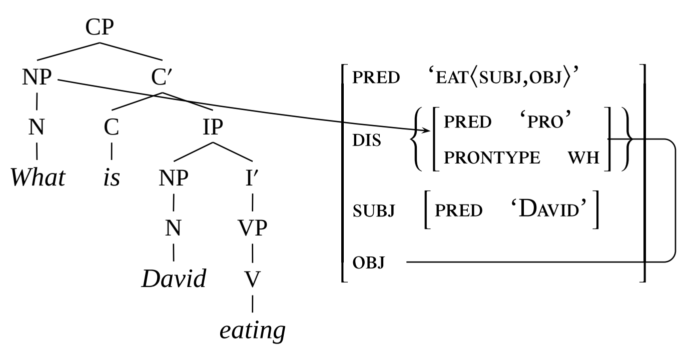
[2]The tree in example (12) has an IP and an I′ node, but no I node; recall from our discussion in Chapter 3, Section 3.7 that no c-structure position is crosslinguistically obligatory, and heads are often optional.

(13) *posadil ded repku.*
planted old.man turnip
'An old man planted a turnip.'



DIS IN SPECIFIER POSITION In English, a question phrase like *what* appears in the specifier position of CP and bears the function DIS, as shown in (14). As discussed in Chapter 2, Section 1.11, DIS (which stands for DISlocation or long DIStance dependency) is an overlay function, and as such it must be integrated into the internal structure of the clause by a relation to a primary, nonoverlay function. It may head an unbounded dependency, as it does in (14), or anaphorically bind a clause-internal function, as in left dislocation structures such as *Chocolate*$_i$, *David loves it*$_i$. In (14), DIS is identified with the OBJ of the verb *eat*.

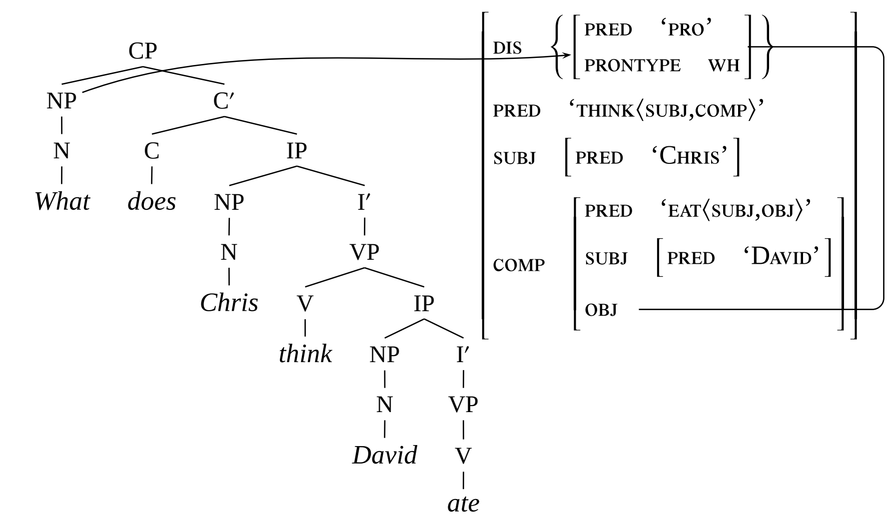
(14) *What is David eating?*



The value of DIS in (14) is a set because more than one constituent can bear the DIS function in a single f-structure. This is the case, for instance, in a version of the sentence in (14) in which *David* is left dislocated: *David, what is he eating?* While this analysis is appropriate for English, the same is not necessarily true for all languages. In this book, we assume unless we are aware of evidence to the contrary that the value of DIS is a set. However, this must be established independently, on a language-by-language basis.

The DIS phrase can also bear a grammatical function in an embedded clause (for more discussion, see Chapter 6, Section 1.2 and Chapter 17). In (15), DIS in the main clause is identified with the OBJ in the subordinate clause:

(15) *What does Chris think David ate?*

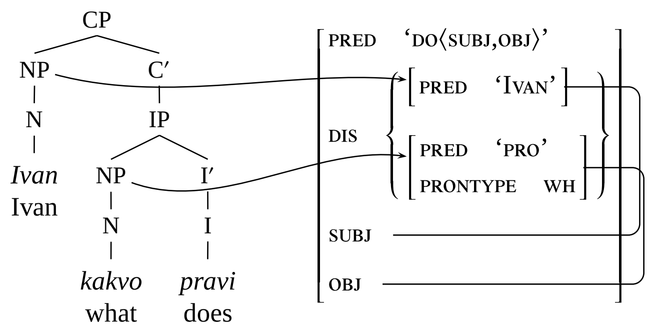


The specifier of CP is also filled by DIS in Russian, as King (1995) shows.

Question phrases in Bulgarian bear the function DIS and fill the specifier position of IP (see Rudin 1985); another DIS can be included in this sentence as well, as example (16) shows. Since more than one DIS can appear in the same clause, as discussed above and shown in (16), the value of the DIS attribute is a set. The difference between the two specifier phrases is one of information structure status: *Ivan* has the information structure function topic, while *kakvo* ‘what’ has the information structure function focus in this sentence.[3]

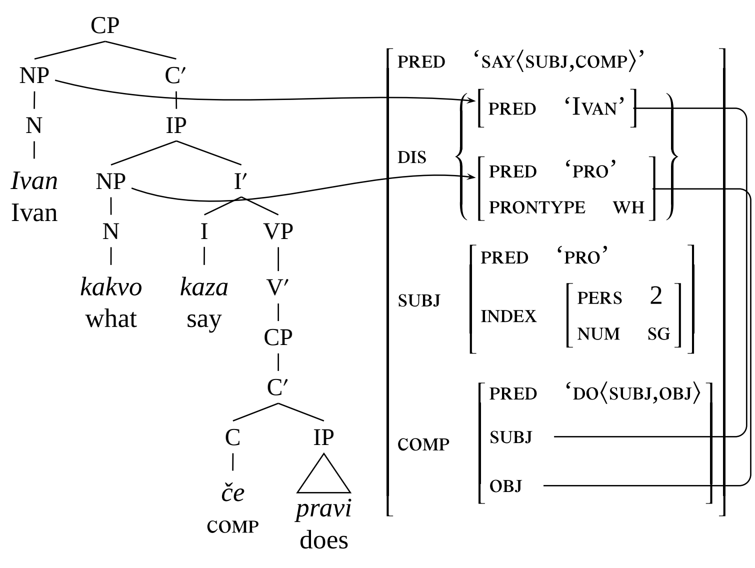
[3] For more on the information structure functions of question words, see Mycock (2013) and Chapter 17.

(16) *Ivan kakvo pravi?*
Ivan what does
'What is Ivan doing?'



Example (17) shows that a phrase in specifier position can play a syntactic role in a subordinate clause. Here, *Ivan* is in the specifier position of CP and *kakvo* is in the specifier position of IP in the main clause; they bear the syntactic roles of SUBJ and OBJ in the subordinate clause.

(17) *Ivan kakvo kaza, če pravi?*
Ivan what say.PST.2SG COMP does
'What did you say that Ivan is doing?'



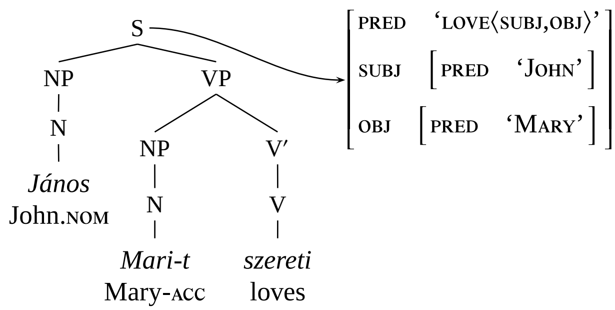
Izvorski (1993) provides further discussion of Bulgarian constituent structure.

Mycock (2006) shows that in Hungarian, the specifier position of VP can be filled by a phrase that bears some grammatical function within the same clause or a subordinate clause, and is associated with the information structure role of focus, which is represented at a separate level of structure to be discussed in Chapter 10; see also Section 2.3.2 below.

(18) Q: *Who does John love?*

A: *János* *Mari-t* *szereti.*
John.NOM Mary-ACC loves

'As for John, it is Mary who he loves.'



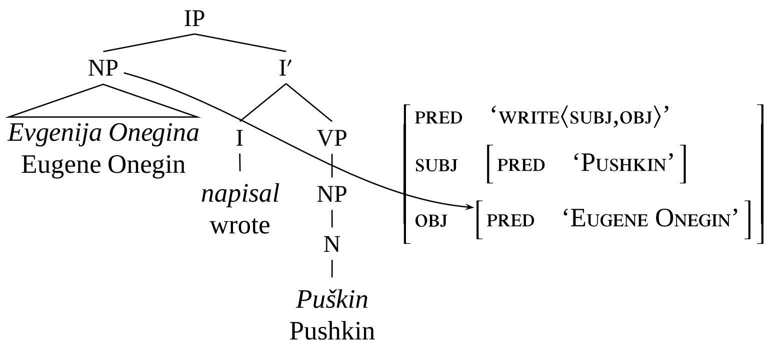
Laczkó (2014a,b) goes further, providing a detailed analysis of the sorts of phrases that can fill the specifier of VP in Hungarian; he argues that besides hosting phrases associated with the information structure role of focus (including question phrases), the specifier of VP can also host verbal modifiers, a category including verbal particles as well as parts of idiomatic expressions and certain object or oblique arguments. He also discusses the consequences of the Hungarian data for LFG assumptions regarding regularities in the c-structure/f-structure mapping.

2.3.2. Information-Structurally Prominent Specifiers

King (1995) shows that in Russian, the phrase appearing in the specifier of IP bears a prominent role at the level of information structure: it is either in focus, or is an internal (new or continuing) topic. Syntactically, the phrase bears an unspecified grammatical function within the same clause, and does not head a long-distance dependency, as was the case in the Hungarian example in (18). We provide more discussion of information structure roles such as topic and focus and their representation in Chapter 10; here we simply discuss the f-structure representation, and note that a phrase with any grammatical role in the clause can fill the specifier of IP.

In (19), the phrase in the specifier of IP *'Evgenija Onegina'*, is a topic and the object of the clause (King 1995, page 206).

(19) *'Evgenija Onegina' napisal Puškin.*
Eugene Onegin wrote Pushkin
'Pushkin wrote 'Eugene Onegin'.'



The specifier of IP in Russian is information-structurally prominent, but not syntactically prominent. It is not associated with the DIS function, since the phrase appearing in the specifier of IP does not control a long-distance dependency: it must bear a grammatical function within the same clause, and cannot be identified with a grammatical function in a different clause. Thus, in (19) *'Evgenija Onegina'* is the object of the clause within which it appears: phrases appearing in the specifier of IP in Russian do not play a syntactic role in a subordinate clause.

2.4. Non-Projecting Words

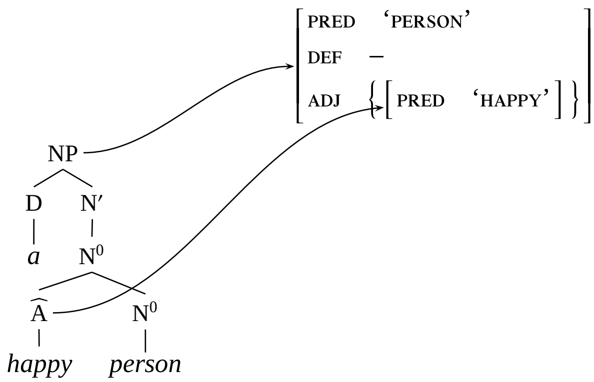
We turn now to the f-structure role of words that do not project full phrases. As discussed in Chapter 3, Section 3.4, we follow Toivonen (2003) in assuming the existence of non-projecting words: that is, lexical and functional categories that are not the heads of full phrases. Toivonen (2003, page 68) proposes the following principle governing the f-structural role of non-projecting categories, according to which non-projecting categories cannot be adjuncts:

(20) Non-projecting words:

Words adjoined to heads are co-heads or argument functions.

Unlike Toivonen, we allow a wider range of f-structure roles for non-projecting words, including adjuncts; this allows an analysis of, for example, English prenominal adjectives in terms of head adjunction, as proposed by Sadler and Arnold (1994) and Arnold and Sadler (2013) and discussed in Chapter 3, Section 3.4. In (21), the non-projecting adjective *happy* is adjoined to the head noun *person*, and appears as a member of the adjunct (ADJ) set at f-structure:

(21) *a happy person*



2.5. Idiosyncratic Constructions and Minor Categories

There is some degree of tension between the general principles relating constituent structure and functional structure which we have been discussing and the demands of idiosyncratic words and constructions in particular languages. Like Kay and Fillmore (1999), LFG aims to provide analyses of idiomatic language patterns as well as the relatively general properties of languages. The need to provide analyses which are crosslinguistically well-motivated and supported by robust typological generalizations must be balanced by the equally important requirement for analyses that are faithful to the phenomenon under analysis; it is important to avoid the danger of forcing a construction with unusual and interesting properties into a more familiar analytic mold.

As discussed in Chapter 3, Section 3.1, some analyses of idiosyncratic words and constructions assume the existence of minor categories such as Part (for Particle) and CL (for Clitic) in addition to the major lexical and functional categories. Such analyses often assume that at least in some instances, the distribution of these minor categories is language dependent and does not fall under the general rules we have been discussing. If we adopt such analyses, we must examine idiomatic, language-specific, or construction-specific syntactic properties of minor categories on a case-by-case basis to determine their properties. Other researchers have proposed generalizations about the f-structural role of these categories; for example, Zaenen (1983) proposes the *Minor category convention*, according to which minor categories are f-structure co-heads:

(22) Minor category convention:

> Minor categories map onto the same f-structure as the node that immediately dominates them.

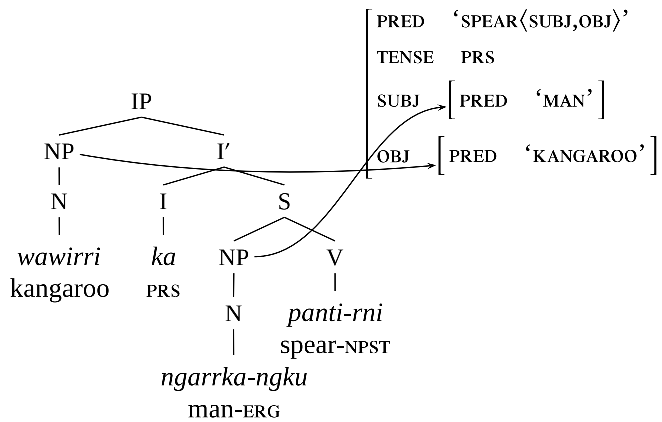
We have not found motivation for assuming minor categories in this work, and so we will not adopt any particular view about the permitted f-structure roles of such categories.

2.6. The Exocentric Category S

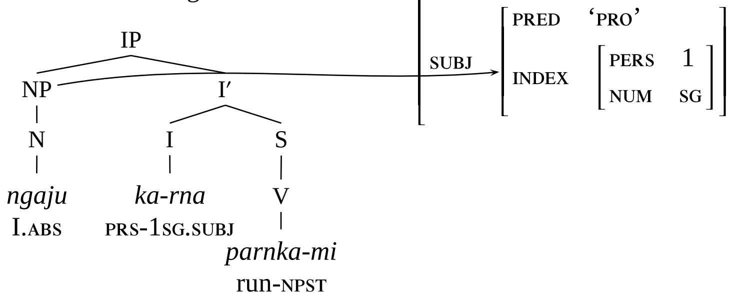
The exocentric category S is not an X′-theoretic category (see Chapter 3, Section 4.2) and does not obey the X′-theoretic generalizations governing the relation between c-structure positions and f-structure functions. Thus, in languages that are unlike English in having the exocentric category S, such as Warlpiri, Tagalog and Malayalam (Austin and Bresnan 1996), phrase structure configuration is not always an unambiguous indicator of grammatical function: phrases with different grammatical functions may appear in the same constituent structure position. For this reason, as Nordlinger (1998) points out, languages with S often allow relatively free word order and rely more heavily on morphological marking than phrase structure configuration for the identification of grammatical functions.

S can dominate phrases with any grammatical function, including SUBJ. In Warlpiri, the subject *ngarrka-ngku* 'man' may appear inside S (Simpson 1991), as shown in example (23a); in contrast, in example (23b) the subject appears outside S.

(23) a. *wawirri ka ngarrka-ngku panti-rni*
kangaroo PRS man-ERG spear-NPST
'The man is spearing the kangaroo.'



b. *ngaju ka-rna parnka-mi*
I.ABS PRS-1SG.SUBJ run-NPST
'I am running.'

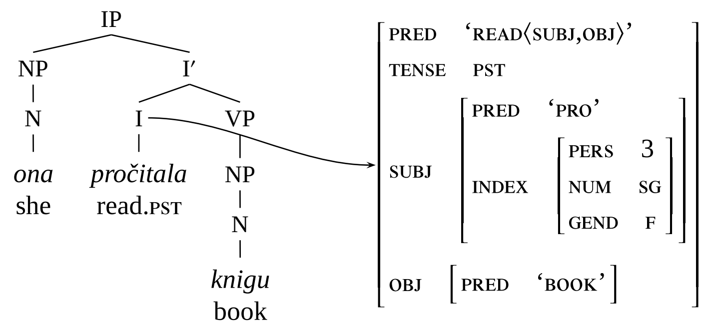


3. "MOVEMENT" AND DISCONTINUITY

3.1. Apparent Head "Movement"

As discussed in Chapter 3, Section 3.7, there are no constituent structure positions that are crosslinguistically obligatory; in particular, the head of a phrase need not be realized. Consider the following Russian example, in which the tensed verb appears in I (King 1995, Chapter 10):

(24) *ona pročitala knigu.*
she read.PST book
'She read the book.'



Examples such as these need no special analysis within LFG, and the verb is not thought of as having "moved" to the position in which it appears. Rather, the principles we have outlined so far predict that this configuration is possible and wellformed. In Russian, all tensed verbs have the phrase structure category I; the verb in (24) appears in I and not within VP. It is not possible for there to be two lexical verbs in a single Russian sentence, one in the I position and one within the VP, since this would produce an ill-formed f-structure; each lexical verb contributes a PRED value to its f-structure, and the Consistency Principle forbids an f-structure from containing a PRED attribute with two different semantic forms as its value. Conversely, a sentence with no verb is ill-formed, since in that case the main f-structure would contain no PRED, and the Completeness Principle would be violated. Exactly one lexical verb must appear, and it must appear in the appropriate position for its constituent structure category. Bresnan et al. (2016, Chapter 7) provide more discussion of such cases, which they refer to as *head mobility* or *variable head positioning*.

3.2. Clitic Doubling

In most dialects of Spanish, full noun phrase objects appear after the verb, while clitic object pronouns appear preverbally. This has been analyzed in other theories as an instance of movement (see, for example, Baltin 1982).

(25) a. *Juan vió a Pedro.*
Juan saw PREP Pedro
'Juan saw Pedro.'

b. *Juan lo vió.*
Juan 3SG.ACC.CLITIC saw
'Juan saw him.'

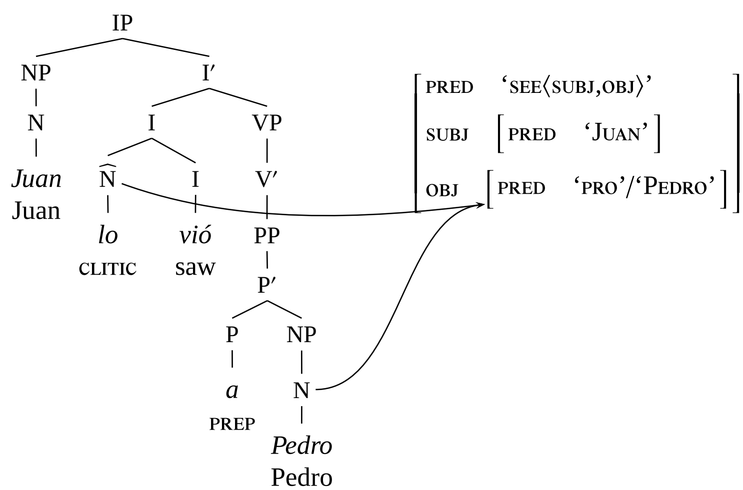
In fact, though, no special analysis is required for Spanish, and no "movement" need be assumed. Two phrase structure positions are associated with the OBJ function in Spanish, a preverbal clitic position and a postverbal phrasal position. If a verb is transitive, an OBJ is required. This means that one of these positions must be filled, and either a clitic or a full noun phrase must appear. In standard Spanish, it is not possible to fill both phrase structure positions: this would cause the OBJ function to be associated with a PRED with two different values, and the Consistency Principle would rule out this ill-formed possibility.

(26) Standard Spanish, no clitic doubling:

**Juan*	*lo*	*vió*	*a*	*Pedro.*
Juan	3SG.ACC.CLITIC	saw	PREP	Pedro

‘Juan saw Pedro.’

Ill-formed f-structure:



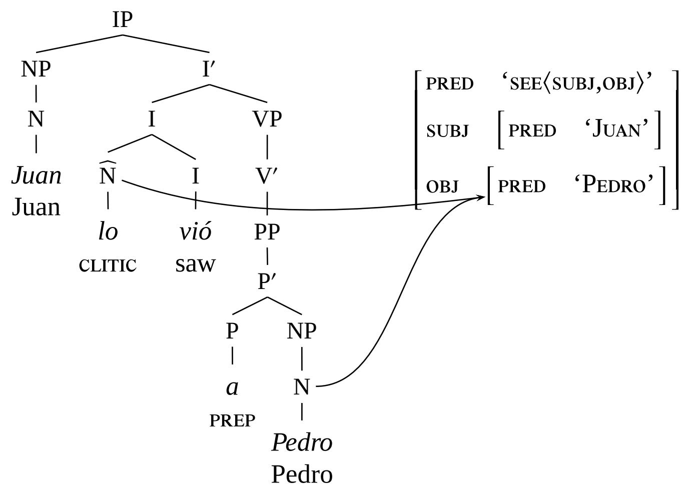
Thus, exactly one object phrase must appear, and it must appear in the constituent structure position appropriate for its phrase structure category.

Interestingly, however, complementary distribution between a clitic and a full noun phrase is not always found. Andrews (1990b) discusses dialects of Spanish which allow *clitic doubling*, in which it is possible for both OBJ positions to be filled, as in (27).

(27) River Plate and Peruvian Spanish, clitic doubling allowed:

Juan lo vió a Pedro.
Juan 3SG.ACC.CLITIC saw PREP Pedro

'Juan saw Pedro.'



Clitic doubling is possible in the River Plate and Peruvian dialects of Spanish as described by Jaeggli (1980) (see also Grimshaw 1982b; Estigarribia 2005; Mayer 2006; Bresnan et al. 2016; and, on Limeño, Mayer 2008). In these dialects, the object clitic pronoun *lo* is undergoing reanalysis as an agreement marker, and has begun to lose its semantic status as a pronominal. Formally, this reanalysis is reflected as *optionality* of the PRED value of the clitic (see Chapter 5, Section 2.4): *lo* need not contribute a PRED value to the f-structure. Since its other features (PERS 3, NUM SG, CASE ACC) are compatible with the full phrasal OBJ, both the clitic and the full noun phrase can appear in the same sentence.

3.3. Category Mismatches

Phrases not appearing in their canonical positions can sometimes exhibit *category mismatches*, as discussed by Kaplan and Bresnan (1982), Kaplan and Zaenen (1989b), and Bresnan et al. (2016, Chapter 2). Kaplan and Bresnan (1982) discuss the verb *think*, showing that it subcategorizes either for a sentential argument as in (28a), or an oblique phrase as in (28b):

(28) a. *He didn't think that he might be wrong.*

b. *He didn't think of his mistake.*

Kaplan and Bresnan (1982) observe that surprising grammaticality patterns emerge when the complement of *think* is displaced, appearing at the beginning of the sentence; they provide the examples in (29) to illustrate this point:

(29) a. **[That he might be wrong] he didn’t think.*

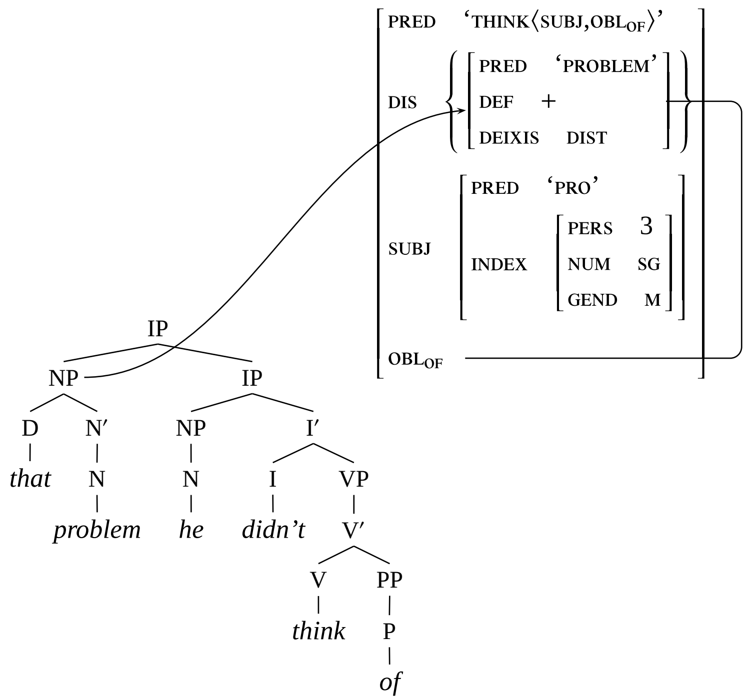
b. **He didn’t think of [that he might be wrong].*

c. *[That he might be wrong] he didn’t think of.*

Example (29a) contrasts in grammaticality with (28a); further, although example (29b) is ungrammatical, example (29c) is fully acceptable. Such examples are mysterious on theories that analyze displaced phrases in terms of phrase structure movement: if we assume that an example like (29a) is derived from a source like (28a) by movement of the complement to initial position, and that (29c) is derived by movement from (29b), it is not clear what would account for their different status.

As noted by Kaplan and Zaenen (1989b) and Dalrymple and Lødrup (2000), a nontransformational account fares better in accounting for instances of apparent mismatch. In LFG, the relation between a sentence-initial constituent in an example like (29c) and its within-clause role is defined at f-structure rather than c-structure. Example (30) shows that English allows preposition stranding, with the sentence-initial phrase *that problem* filling the role of object of the stranded preposition *of*:

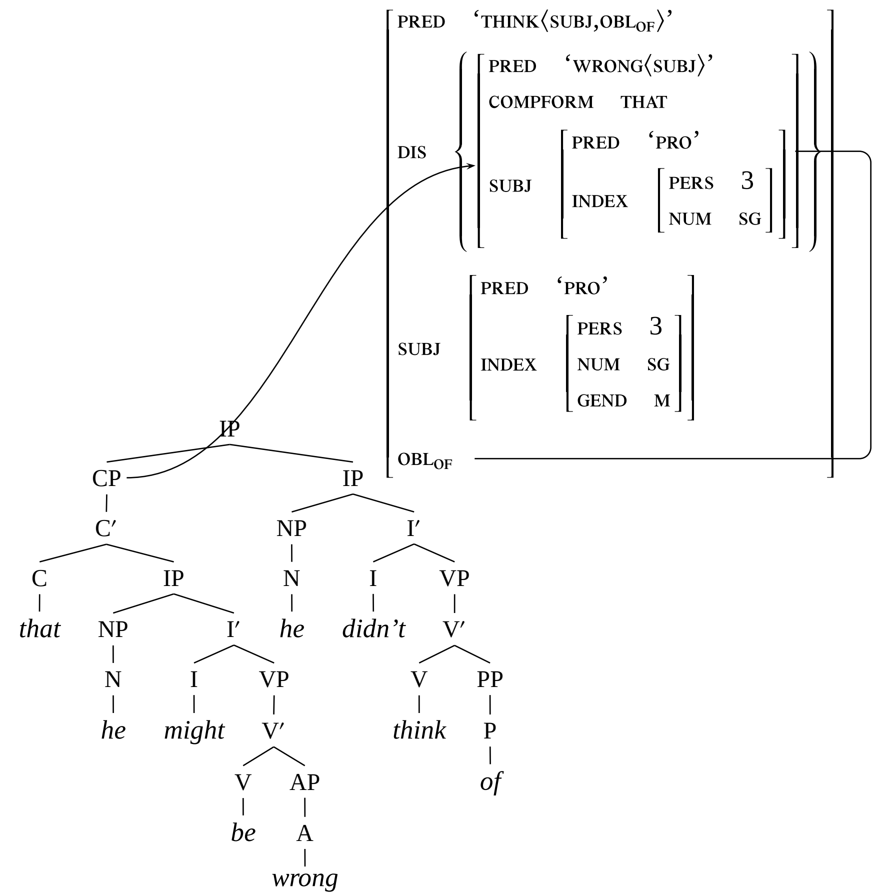
(30) *That problem, he didn't think of.*



In (30), there is no sense in which the phrase *that problem* has been moved to clause-initial position from a position within the clause. Rather, the relation between the initial NP and its within-clause function is specified in functional rather than constituent structure terms, by functional uncertainty (see Chapter 6, Section 1.2), and phrase structure category is not a part of the specification. Exactly the same constraints allow for a clause-initial CP to fill the role of object of the preposition *of*, as shown in (31):[4]

[4]The f-structure for the clause *that he might be wrong* has been simplified; the functional structure of copular constructions is discussed in detail in Chapter 5, Section 4.5.

(31) *That he might be wrong he didn't think of.*

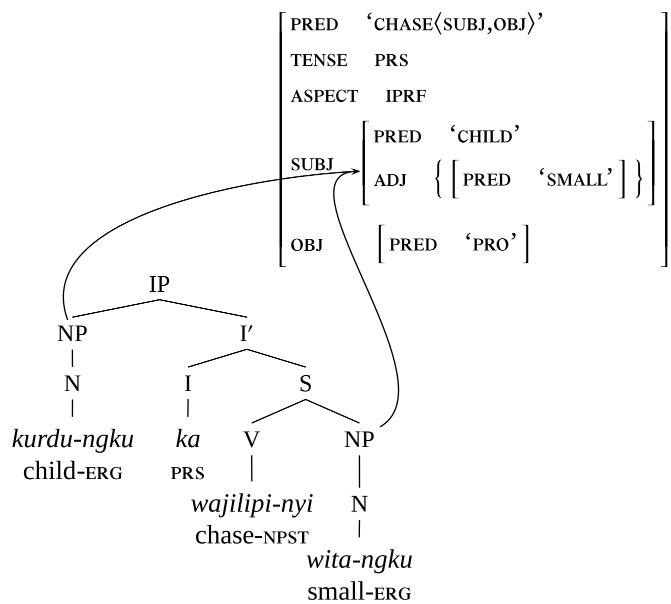


Example (29a) is ruled out by functional constraints on extraction relations: in particular, the clausal complement of *think* (as opposed to *think of*) is a COMP, which, at least in English, cannot participate in constructions involving displacement. In contrast, example (29b) is ruled out as an impossible c-structure configuration: a preposition such as *of* does not take a CP as its complement at c-structure.

3.4. Constituent Structural Discontinuity

Simpson (1991, Chapter 5) provides a very interesting discussion of nonconfigurationality and discontinuity in an LFG setting (see also Austin and Bresnan 1996, Kuhn 2001c, and Bresnan et al. 2016). Simpson shows that the subject of a Warlpiri sentence can appear as a daughter of S (as in example 23a) as well as in the specifier position of IP (as in example 23b). As we would expect, then, phrases in each of these positions — or, crucially, in *both* positions — can contribute to the structure of the SUBJ of a sentence. In the "merged" reading[5] of example (32), parts of the SUBJ appear in S while other parts appear in the specifier of IP: the SUBJ phrase *kurdu-ngku* 'child' appears in the specifier of IP, while a modifier of the SUBJ, *wita-ngku* 'small', appears within the S. Since Warlpiri is a pro-drop language, the OBJ is not represented in the c-structure tree (see Section 1 of this chapter).

(32) *kurdu-ngku ka wajilipi-nyi wita-ngku*
child-ERG PRS chase-NPST small-ERG
'The small child is chasing it.'



These two phrases are functionally compatible, since both bear ERG case: one represents the head of the subject phrase, and the other represents a modifier. Here too, we need say nothing special about examples involving constituent structural discontinuity such as these; our theory predicts that they will occur, and we need no special analysis to encompass them.

[5]There is no categorical distinction between adjectives and nouns in Warlpiri, and we follow Simpson in categorizing both *kurdu-ngku* 'child' and *wita-ngku* 'small' as nouns. Simpson shows that there are two readings for example (32); in the merged reading, the one which is of interest here, *wita-ngku* 'small' is interpreted as a restrictive modifier of *kurdu-ngku* 'child'. The other reading is the nonrestrictive, "unmerged" interpretation, which Simpson paraphrases as 'The child is chasing it and she is small'; on Simpson's analysis, this reading has a different syntactic structure.

4. THE LEXICAL INTEGRITY PRINCIPLE

The *Lexicalist Hypothesis* was first discussed within a transformational setting by Chomsky (1970), who advanced the claim that rules of word formation are lexical rather than transformational: words and phrases are built up from different elements and by different means. The hypothesis exists in two forms. Its weaker form (the "weak lexicalist hypothesis") states that the lexicon consists of all roots formed by derivational morphology, and that roots are not formed by transformational rules. However, on this view inflectional morphemes may be treated as seperate syntactic units from the root, occupying separate nodes in the phrase structure tree.

Bresnan (1978) adopts a stronger form of the hypothesis, claiming that "syntactic transformations do not play a role in word formation," either in derivational or inflectional morphology. Lapointe (1980) builds on this claim, proposing what is usually called the "strong lexicalist hypothesis" or the *Lexical Integrity Principle*:[6]

(33) Lexical Integrity Principle, Lapointe (1980, page 8): No syntactic rule can refer to elements of morphological structure.

Bresnan et al. (2016) state the principle in the following way:

(34) Lexical Integrity Principle, Bresnan et al. (2016, page 92): Morphologically complete words are leaves of the c-structure tree, and each leaf corresponds to one and only one c-structure node.

Current work in LFG adheres to this principle: LFG does not assume the existence of processes that assemble word forms in constituent structure or reorder subparts of word forms during syntactic composition. In this way, the LFG view contrasts with approaches such as Distributed Morphology (Halle and Marantz 1993; Embick and Noyer 2007) and the Exo-Skeletal Model (Borer 2013), which reject the Lexicalist Hypothesis. We will not address this controversy in detail here; cogent defenses of the Lexicalist Hypothesis are provided by Bresnan and Mchombo (1995), Spencer (2005b, 2016), Stewart and Stump (2007), and references cited there. We provide a detailed discussion of the role of morphology in the LFG architecture in Chapter 12.

Although words are not subject to processes of assembly in the constituent structure, their syntactic contributions can be complex. A word that forms a unit at the level of c-structure may introduce complex functional structure, structure that in other languages might be associated with a phrase rather than a single word. For example, Bresnan and Mchombo (1987) present evidence that subject and object markers on the Chicheŵa verb can function as incorporated pronouns. These affixes form a part of the verb at c-structure, meaning that the f-structure corresponding to this verb is complex, similar to the f-structure for a sentence in

[6] Lapointe (1980) refers to this as the "generalized lexicalist hypothesis".

a language like English.[7] In (35), the marker *zi-* represents a pronominal SUBJ of noun class 10, and the marker *-wá-* represents a pronominal OBJ of noun class 2:

(35)

$$\begin{array}{c} \text{V} \\ | \\ \textit{zi-ná-wá-lúm-a} \\ \text{10SUBJ-PST-2OBJ-bite-IND} \\ \text{`They bit them.'} \end{array} \longrightarrow \begin{bmatrix} \text{PRED} & \text{`BITE}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`PRO'} \\ \text{NOUNCLASS} & 10 \end{bmatrix} \\ \text{OBJ} & \begin{bmatrix} \text{PRED} & \text{`PRO'} \\ \text{NOUNCLASS} & 2 \end{bmatrix} \end{bmatrix}$$

As this example shows, the notion of word is multifaceted and must be fully defined at each syntactic level of representation; units at c-structure need not correspond to simple units at other levels.

Much other work has been done within LFG in support of the strong lexicalist hypothesis, demonstrating convincingly that a word that is atomic at the level of c-structure can project the structure of a phrase at functional structure. Simpson (1983, 1991), Ackerman (1987), O'Connor (1987), Mohanan (1994, 1995), Bresnan and Mchombo (1995), Nordlinger and Bresnan (1996), Matsumoto (1996), Sadler (1997), Ackerman and LeSourd (1997), Börjars (1998), Alsina (1999), Broadwell (2008), Asudeh et al. (2013), and Lowe (2016b) have all made valuable contributions to our understanding of wordhood and lexical integrity.

5. ECONOMY OF EXPRESSION

The principle of *Economy of Expression* requires the choice of the simplest and smallest c-structure tree that expresses the intended meaning while also obeying wellformedness conditions on c-structures and corresponding to a wellformed f-structure. Economy of Expression is formulated by Bresnan et al. (2016) as follows:

(36) Economy of Expression:

> All syntactic phrase structure nodes are optional and are not used unless required by independent principles (Completeness, Coherence, Semantic expressivity). (Bresnan et al. 2016, page 90)

Since a node may be used only if it is required by independent principles to express a particular meaning, speakers are required to choose the most economical way of expressing a meaning, where economy is measured in terms of the number of nodes in the c-structure tree. That is, if there is more than one possible

[7] See Chapter 5, Section 4.3 and Chapter 14, Section 1 for more discussion of the pronominal status of the subject and object markers in Chicheŵa.

c-structure tree for an utterance, the correct tree is the one with the smallest number of nodes.

The effects of the Economy metric are dependent on the independently-specified wellformedness conditions on c-structure trees that are assumed. For example, according to the version of X′ theory assumed by Bresnan et al. (2016) and in this book, a nonbranching X′ node is not required. In this setting, Economy disallows trees with a nonbranching single-bar-level category X′, since the X′ node is not necessary to express the intended meaning, and the tree without the X′ node has fewer nodes. Given a choice between the following two trees, then, Economy mandates the choice of the tree in (37b) and not the tree in (37a):

(37) Bresnan et al. (2016):

Uneconomical tree (disallowed):	Economical tree:
NP	NP
N′	N
N	*David*
David	

Toivonen (2003) proposes a slightly different definition of Economy:

(38) Economy of Expression: All syntactic phrase structure nodes are optional and are not used unless required by X′-constraints or Completeness. (Toivonen 2003, page 200)

Toivonen assumes a stricter version of X′ theory, according to which the X′ node may not be omitted. Her stricter version of X′ theory leads to the choice of a different tree as the correct one for the NP *David*; on her view, the smaller tree is not wellformed and may not be selected.

(39) Toivonen (2003):

Wellformed tree:	Ill-formed tree violating X′ theory (disallowed):
NP	NP
N′	N
N	*David*
David	

Both definitions of Economy proceed from the claim that every node in a c-structure tree is optional. In fact, the issue of optionality of nodes as a general principle of the grammar is separable from particular definitions of an Economy principle. As discussed in Chapter 3, Section 3.7, there are no phrase structure positions that are obligatory in every phrase and in every language: a phrase XP need not dominate a head X in the tree, and the complements of a lexical predicate X need not appear as sisters to X. However, Snijders (2012, 2015) shows that in some configurations in some languages, c-structure nodes are obligatory and not optional: in particular, Snijders shows that the NP complement of P in the Latin PP is obligatory. The existence of obligatory nodes is not incompatible with the adoption of an Economy principle: even if some nodes in some constructions are obligatory, an Economy measure can still be used to choose among larger and smaller trees that otherwise obey the rules of the grammar.

Dalrymple et al. (2015) discuss the various versions of Economy which have been proposed, providing explicit formal definitions of three versions of the Economy metric, and an overview of analyses which have appealed to an Economy measure. They discuss whether Economy is best treated as a very general principle, as on Toivonen's and Bresnan et al.'s approaches, or if it is preferable to appeal to more specific principles for particular subcases rather than a general Economy principle.

6. FURTHER READING AND RELATED ISSUES

There has been a great deal of work in LFG on the relation between constituent structure and functional structure in a typologically diverse set of languages. Of particular note, besides the works mentioned earlier, are Johnson (1986), Dahlstrom (1987), Kaplan and Zaenen (1989b), and Huang (1990), who discuss discontinuity, phrasal constituency, and the c-structure/f-structure relation; Lee (2001) and Mahowald (2011) on word order freezing; and Sells (2000b), who discusses evidence from raising in Philippine languages and its bearing on clause structure. Bresnan et al. (2016, Chapter 5) provides a lucid discussion of the *fragmentability of language*, the fact that the c-structure and f-structure of sentence fragments can be easily inferred based on lexically and phrasally specified constraints on syntactic structures. Butt et al. (1999) present a comparative overview of English, French, and German constituent and functional structures and the relation between them, discussing a wide range of syntactic constructions and issues that arise in the analysis of these languages.

5

DESCRIBING SYNTACTIC STRUCTURES

Up to this point, our discussion has concentrated on the nature and representation of the two syntactic structures of LFG. We will now demonstrate how to formulate descriptions of and constraints on c-structure, f-structure, and the relation between them, and we will see how these constraints are important in the statement of universal typological generalizations about linguistic structure. These constraints are a part of the *formal architecture* of LFG theory.

The job of the designer of a formal linguistic framework such as LFG is to provide a way of stating linguistic facts and generalizations clearly and precisely, in a way that is conducive to a solid understanding of the linguistic structures that are described and how they are related. Designing an appropriate representation for a linguistic structure is very important in helping the linguist to understand it clearly and in avoiding confusion about the properties of the structure and its relation to other structures. A formal linguistic theory must provide efficient and transparent ways of describing the facts of a language. Linguistically important generalizations should be easy to express, and the linguistic import of a constraint should be evident.

The job of a linguist working within a formal framework is to discover the facts of a language or of languages and to express these facts by using the tools provided by the designer of the framework so that the linguistic facts emerge precisely and intuitively. Most importantly, the linguist must distinguish between constraints that are needed and used in describing the facts of language, the *linguistically relevant* constraints, and those that may be expressible within the overall formal framework but do not play a role in linguistic description. A well-designed formal framework aids the linguist in deciding which constraints are relevant and which are not in the description of linguistic structures.

1. CONSTITUENT STRUCTURE RULES

1.1. Phrase Structure Rules

Most linguistic theories that represent phrasal information in terms of phrase structure trees make use of *phrase structure rules* to determine the possible and admissible phrase structure configurations in a language:

(1) S $\longrightarrow$ NP VP

This rule permits a node labeled S to dominate two nodes, an NP and a VP, with the NP preceding the VP. In LFG, phrase structure rules are interpreted as node admissibility conditions, as originally proposed by McCawley (1968): a phrase structure tree is admitted by a set of phrase structure rules if the rules license the tree. In other words, phrase structure rules are thought of as descriptions of admissible trees, and the trees of the language must meet these descriptions. McCawley's groundbreaking work constituted an important alternative to the way of thinking about phrase structure rules that was prevalent in the mid-1960s, which viewed phrase structure rules as a procedural, derivational set of instructions to perform a series of rewriting steps.

In many theories of phrase structure specification, all phrase structure rules are of the type illustrated in (1): the right-hand side of the rule (here, NP VP) specifies a particular unique admissible configuration. Constituent structure rules in LFG are more expressive than this, in that the right-hand side of a phrase structure rule consists of a *regular expression* (Kaplan and Bresnan 1982, page 277; see Chapter 6, Section 1 for a full discussion and definition of regular expressions). The use of a regular expression allows a sequence of category labels in which some categories may be optional, some categories may be repeated any number of times, and disjunction is permitted.

Since phrase structure rules represent constraints on phrase structure configurations, it is reasonable and desirable to abbreviate a large or even an infinite number of rules by means of a regular expression. A phrase structure rule is not thought of as a large or infinite set of rules that can be applied individually in a series of rewriting steps, but as a characterization of the daughters that nodes of a phrase structure tree can dominate. This constraint-based view of linguistic descriptions pervades the formal theory of LFG: a grammar of a language consists of a set of constraints on linguistic structures, and these constraints admit only wellformed analyses of utterances.

A simple LFG phrase structure rule can have the following form:

(2) IP ⟶ {NP | PP} I′

This rule indicates that either an NP or a PP can appear in the specifier position of IP. The curly brackets mark a disjunction of phrase structure categories, with the possibilities separated by a vertical bar |. This rule abbreviates the following two rules, where the disjunction in (2) has been fully expanded into two separate rules:

(3) a. IP ⟶ NP I′
    b. IP ⟶ PP I′

The abbreviation in (2) is not only more compact than the two-fold expansion in (3), but more revealing of the linguistic facts: the specifier position of IP can be filled either by NP or by PP without affecting any properties of the second daughter of IP, namely I′. Stating this fact by means of two separate rules, as in (3), makes it appear that the I′ might have different properties in the two different rules, since there is no apparent relation between the I′ in the first rule and the I′ in the second rule.

In (4), the parentheses around the NP indicate optionality. The *Kleene star* annotation * on the PP indicates that zero or more PPs may appear in the expansion of the rule; more discussion of the meaning and use of the Kleene star is given in Chapter 6, Section 1:

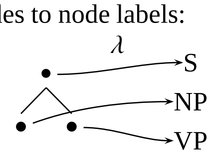
(4) V′ ⟶ V (NP) PP*

Thus, this rule admits trees in which a V′ node dominates a V, an optional NP, and any number of PPs. The use of the Kleene star means that an infinite set of possible rules — rules with any number of PPs — can be abbreviated with a single expression. Thus, phrase structure generalizations can be stated once rather than separately for each specific phrase structure configuration licensed by the rule.

1.2. Node Labels

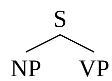
The rule in (1) admits a tree in which a node labeled S dominates two nodes, one labeled NP and the other labeled VP. Generally, we refer to a node of a tree by its label, and so we talk of the S, NP, or VP nodes in the tree. In fact, however, S, NP, and VP are *node labels*, and each node of the tree is related to its label by the labeling function λ (Kaplan 1995). To be completely explicit, then, we could represent a tree and its node labels in the following more cumbersome way, with dots representing the nodes themselves, and arrows representing the λ function from nodes to node labels:

(5)



We generally follow standard practice in displaying trees with node labels representing the nodes which they label, meaning that we represent the tree in (5) as in (6). The node labeling function λ will occasionally be important in our subsequent discussion, however.

(6)



1.3. C-Structure Metacategories

Example (2) illustrates the use of disjunction over a set of categories in a rule. It is also possible to introduce an abbreviation over a set of categories in a rule: for instance, an abbreviation like XP is often used to represent a set of categories that behave similarly in some way. In such a situation, XP is a *c-structure metacategory* representing several different categories.

King (1995) uses metacategory abbreviations like the following in her analysis of Russian:

(7) CP $\longrightarrow$ XP C′
IP $\longrightarrow$ XP I′

The use of XP in these rules indicates that a full phrase of any category (NP, PP, and so on) can appear as the first daughter of CP and IP. XP is defined as follows:[1]

(8) XP ≡ {NP | PP | VP | AP | AdvP }

The use of abbreviations like this allows for the expression of general statements about all phrases that appear in a particular phrase structure position.

In (8), the metacategory XP stands for any one of a number of phrasal categories. In fact, a metacategory can abbreviate a longer sequence of categories, not just a single category (Kaplan and Maxwell 1996). This is shown in the following putative definition of the metacategory PREDICATE:

(9) PREDICATE ≡ V NP

More generally, a metacategory can be used as an abbreviation for any regular predicate over categories. What do such abbreviations mean, and how are they used?

An abbreviation like PREDICATE ≡ V NP can be used to express a generalization about where a sequence of categories like V NP can appear in the grammar *without* introducing a node dominating those categories into the tree. Instead, wherever a phrase structure rule refers to the metacategory PREDICATE, the sequence of categories V NP is permitted to appear in the phrase structure tree. For example, we can interpret the rule in (10) as referring to the definition of PREDICATE given in (9):

[1] The symbol ≡ connects two expressions that are defined to be equivalent; the expression in (8) can be read as: "XP is defined as the disjunction {NP | PP | VP | AP | AdvP}"; that is, XP is a phrase with category NP, PP, VP, AP, or AdvP.

(10) S $\longrightarrow$ NP PREDICATE

Given this definition, the rule in (11) produces exactly the same result as the rule in (10):

(11) S $\longrightarrow$ NP V NP

The phrase structure rule in (10) and the definition of VP in (9) admit the following tree:

(12)
```
      S
  ____|____
 NP   V   NP
```

Notably, there is no PREDICATE node in this tree.

The possibility of using a metacategory to characterize a sequence of categories in this way has an interesting impact on one of the clearest traditional motivations for phrase structure constituency, described in Chapter 3, Section 1: generalizations governing the distribution of sequences of categories. In many theories of phrase structure, the fact that a phrase like *the dachshund* has the same syntactic distribution as a phrase like *the black dachshund* is taken as evidence that both phrases are constituents that are dominated by an NP node; on this view, generalizations about the distribution of the category sequence Det (A) N are stated in terms of the distribution of an NP constituent. The use of a metacategory like VP in the rule in example (11) allows for the statement of generalizations about sequences of categories in the same way. Importantly, however, the resulting phrase structure tree does not contain a constituent labeled VP: the V NP sequence does not form a phrasal unit in the constituent structure tree.

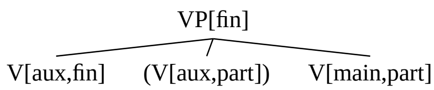
It is interesting to note that some (but not all) of the criteria for phrase structure constituenthood presented in Chapter 3, Section 2 are based in part on the distribution of sequences of categories. Further research may reveal more about the possibility and desirability of capturing generalizations about category distribution by means of metacategories defined over sequences of categories, rather than by assuming the existence of a phrasal constituent dominating these categories in the constituent structure tree.

1.4. Complex Categories

Constraints on phrase structure may involve fine-grained specifications over subtypes of standard categories like VP or V. Such patterns can be captured by the use of *complex categories* involving parametrization of c-structure categories.

For example, as discussed in Chapter 3, Section 3.5, Frank and Zaenen (2002) assume a nonstandard flat structure for the French VP in their analysis of auxiliary selection in French. They propose that the VP category is *parametrized* for finiteness, and the V category is parametrized for finiteness and verb type. Notationally, parameters of a category are written in square brackets after the category: VP[fin] is a VP with the feature fin(ite), and V[fin] is a finite V. According to this analysis, one acceptable VP configuration in French is shown in (13), where a VP[fin] consists of a finite auxiliary verb, an optional participial auxiliary, and a participial main verb.

(13) Frank and Zaenen (2002, page 51):



This pattern can be generalized to other values for finiteness by using *parametrized rules* to allow information about these features to flow through the c-structure tree, placing fine-grained constraints on how different subtypes of categories can be realized. In Frank and Zaenen's grammar there are three possible instantiations of the finiteness parameter: fin (finite), inf (infinitive), and part (participle). The requirement for identical values of the finiteness parameter for the VP and the initial V is captured by the use of variables over features. Notationally, parameter variables are prefixed by an underscore: VP[_ftness] and V[main,_ftness] both contain occurrences of the variable _ftness. Within the same configuration, identical variables must match. This means that the rule in (14a) is a succinct abbreviation of the three rules in (14b):

(14) a. VP[_ftness] ⟶ V[main,_ftness]

b. VP[fin] ⟶ V[main,fin]

VP[inf] ⟶ V[main,inf]

VP[part] ⟶ V[main,part]

Thus, the rule in example (15) licenses the c-structure in example (13), as well as any other c-structures in which the finiteness value of the initial V daughter matches the finiteness value of the VP.

(15) VP[_ftness] ⟶ V[aux,_ftness] (V[aux,part]) V[main,part]

This analysis requires the French finite auxiliary *est* to have the parametrized category V[aux,fin]:

(16) *est*: V[aux,fin]

We return to a discussion of parametrized categories in Chapter 12, Section 2.2, where we will see how the morphological component of the grammar determines the c-structure category of a word form like *est*, including the parameters of a complex category.

1.5. Immediate Dominance and Linear Precedence Rules

Immediate Dominance/Linear Precedence rules were introduced by Gazdar and Pullum (1981), and independently developed within the LFG framework by Falk (1983), to allow dominance relations to be stated separately from precedence relations in phrase structure rules. Dominance relations are stated in terms of Immediate Dominance or ID rules, and precedence constraints are stated in terms of Linear Precedence or LP rules. These rules allow the statement of generalizations across families of phrase structure rules: for example, that the head of a phrase of any category precedes its complements in a head-initial language.

An ID rule expressing only dominance relations is written with commas separating the daughter nodes in the rule:

(17) VP ⟶ V, NP

This rule states that a VP node dominates two other nodes in a tree, a V node and a NP node, but does not specify the order of V and NP. Thus, it can be regarded as an abbreviation for the two rules in (18), in which the order is fully specified:

(18) VP ⟶ V NP
VP ⟶ NP V

If we wish to specify the order, we can write a separate LP ordering constraint:

(19) VP ⟶ V, NP   V<NP

The ID phrase structure rule in (17), combined with the linear precedence constraint V<NP stating that V must precede NP, is equivalent to the standard ordered phrase structure rule VP ⟶ V NP. A more complicated example is given in (20):

(20) VP ⟶ V, NP, PP   V<NP, V<PP

The ID phrase structure rule requires VP to dominate three nodes, V, NP, and PP. The LP ordering constraints require V to precede both NP and PP, but do not place any constraints on the relative order of NP and PP. Thus, the ID rule and constraint in (20) are equivalent to the rule in (21), in which ordering is fully specified, and NP appears either before or after PP:

(21) VP ⟶ V {NP PP | PP NP}

ID/LP rules are used in King's (1995) analysis of Russian. She proposes rules of the following form:

(22) a. CP ⟶ XP, C′
b. C′ ⟶ C, IP
c. IP ⟶ XP, I′
d. XP<Y′, Y<XP

XP is defined as a metacategory over any maximal phrasal category, Y′ is a metacategory over any nonmaximal category of bar level one, and Y is a metacategory over any lexical or functional category of bar level zero. The constraint XP<Y′ means that the specifier XP of a phrase of category Y appears before the head Y′, determining the order of the daughters for rules (22a) and (22c). The constraint Y<XP means that the head Y appears before its complement phrase XP, determining the order for rule (22b).

In Chapter 6, Section 1.1, we discuss more complicated constraints on c-structure configurations, including the use of combinations of regular expressions in defining phrase structure rules.

2. FUNCTIONAL CONSTRAINTS

Just as we have ways of talking about the set of permissible trees in a language, we would also like to have a way of describing acceptable f-structures. In the following, we discuss how simple constraints on functional structure are interpreted and when these constraints are satisfied. Chapter 6 provides more discussion of c-structure and f-structure constraints.

Formally, an f-structure is a set of attribute-value pairs, or a function from attributes to values, as discussed in Chapter 2, Section 4. The usual way of presenting an f-structure is in tabular form (that is, as a table):[2]

(23) $\begin{bmatrix} \textsc{pred} & \text{`}\textsc{man}\text{'} \\ \textsc{def} & + \end{bmatrix}$

The f-structure in (23) contains two attribute-value pairs: $\langle \textsc{pred}, \text{`}\textsc{man}\text{'} \rangle$ and $\langle \textsc{def}, + \rangle$. We can place various requirements on f-structures: they may be required to contain certain attribute-value pairs or one of several possible attribute-value pairs, or they may be required not to contain certain material. The following sections explain how such constraints can be imposed.

2.1. Functional Equations

The equation in (24) specifies the f-structure named *m* as having an attribute DEF whose value is +:

(24) $(m\ \textsc{def}) = +$

This is a simple *functional description* or *f-description*. This f-description consists of only a single equation, but f-descriptions can in general consist of any number of such equations.

The f-structure labeled *m* in (25) satisfies the constraint in (24), since it has an attribute DEF with value +:

(25) $m\begin{bmatrix} \textsc{def} & + \end{bmatrix}$

An equation requiring an attribute *a* of an f-structure to have a certain value *v* holds if (and only if) the pair consisting of the attribute *a* and its value *v* belongs to the f-structure.

[2]As explained in Chapter 2, Footnote 21 (page 48), what is depicted in example (23) is an f-structure, a formal object, not a constraint on f-structures.

There are many other f-structures (in fact, an infinite number) that also satisfy the constraint in (24). Any f-structure that has an attribute DEF with value + as well as additional attributes and values satisfies the constraint; for example:

(26)
$$m\left[\begin{array}{ll} \text{PRED} & \text{`MAN'} \\ \text{DEF} & + \\ \text{DEIXIS} & \text{PROX} \end{array}\right]$$

This f-structure, which represents the expression *this man*, contains the attribute DEF with value +; it also contains additional attributes and values.

The f-structure in (25) is special in that it is the *smallest* f-structure that satisfies the constraint in (24). We call such an f-structure the *minimal solution* to the f-description in (24): it satisfies all the constraints in the f-description, and it has no additional structure that is not relevant in satisfying the constraints.

We require the f-structure for any utterance to be the smallest f-structure that satisfies all of the constraints imposed by the f-description for the utterance, and has no additional properties not mentioned in the f-description:

(27) The f-structure for an utterance is the *minimal solution* satisfying the constraints introduced by the words and phrase structure of the utterance.

The f-description for an utterance is given by annotations on the phrase structure rules and the lexical entries involved in the utterance. In Section 3 of this chapter, we discuss how annotated phrase structure rules and lexical entries give rise to an f-description for a phrase.

Kaplan and Zaenen (1989b) provide the following formal characterization of when an equation like the one in (24) holds of an f-structure:[3]

(28) $(f\ a) = v$ holds if and only if f is an f-structure, a is a symbol, and the pair $\langle a, v\rangle \in f$.

It is also possible for an expression to involve multiple attribute names — that is, a longer path through the f-structure:

(29) $(f\ \text{SUBJ DEF}) = +$

For these cases, the following definition is relevant (Kaplan and Bresnan 1982; Kaplan and Zaenen 1989b):[4]

(30) $(f\ as) \equiv ((f\ a)\ s)$ for a symbol a and a string of symbols s.

$(f\ \epsilon) \equiv f$, where ϵ is the empty string.

This definition tells us that an expression like $(f\ \text{SUBJ DEF})$ denotes the same f-structure as $((f\ \text{SUBJ})\ \text{DEF})$: that is, the f-structure that appears at the end of the

[3] The symbol $\in$ is the *set-membership* symbol: the expression $x \in Y$ ("x is in (the set) Y") means that x is a member of the set Y. Chapter 6, Section 3 provides a detailed discussion of predicates and relations involving sets.

[4] The epsilon symbol ϵ, which represents the empty string or path, is not the same as the set membership symbol $\in$.

path SUBJ DEF in the f-structure f is the same f-structure that appears as the value of the attribute DEF in the f-structure $(f\ \text{SUBJ})$. Longer expressions are treated similarly. The second part of the definition tells us that the empty path ϵ can be ignored: the expression $(f\epsilon)$ is the same as f.

A Hindi sentence like (31) (McGregor 1972) is associated with the f-description given in (32) and (33) (some detail has been omitted):

(31) *Ram calegaa*
Ram go.FUT.3M.SG
'Ram will go.'

The constraints in (32) come from the lexical entries for the proper noun *Ram* and the verb *calegaa* 'will go'; here, we consider only CASE and NUM requirements imposed by the verb on its subject, ignoring tense, person, and gender features:

(32)

(32)	*Ram*	$(r\ \text{PRED}) = \text{'RAM'}$
		$(r\ \text{INDEX NUM}) = \text{SG}$
		$(r\ \text{CONCORD CASE}) = \text{NOM}$
	calegaa	$(c\ \text{PRED}) = \text{'GO}\langle\text{SUBJ}\rangle\text{'}$
		$(c\ \text{SUBJ INDEX NUM}) = \text{SG}$
		$(c\ \text{SUBJ CONCORD CASE}) = \text{NOM}$

We also know that *Ram* is the subject of this sentence: that is, the f-structure r for *Ram* is the SUBJ of the f-structure c for the sentence. This is encoded in the constraint in (33):

(33) $(c\ \text{SUBJ}) = r$

Given this equality, we can substitute r for $(c\ \text{SUBJ})$ in the constraints in (32). We are then left with the set of constraints in (34), which are equivalent to the constraints in (32).

(34) $(r\ \text{PRED}) = \text{'RAM'}$
$(r\ \text{INDEX NUM}) = \text{SG}$
$(r\ \text{CONCORD CASE}) = \text{NOM}$

$(c\ \text{PRED}) = \text{'GO}\langle\text{SUBJ}\rangle\text{'}$
$(r\ \text{INDEX NUM}) = \text{SG}$
$(r\ \text{CONCORD CASE}) = \text{NOM}$

$(c\ \text{SUBJ}) = r$

The minimal solution to this f-description — the f-structure that satisfies the f-description and contains no additional attribute-value pairs — is:

(35)
$$c\left[\begin{array}{ll}\text{PRED} & \text{'GO}\langle\text{SUBJ}\rangle\text{'}\\ \text{SUBJ} & r\left[\begin{array}{ll}\text{PRED} & \text{'RAM'}\\ \text{INDEX} & \left[\text{NUM} \quad \text{SG}\right]\\ \text{CONCORD} & \left[\text{CASE} \quad \text{NOM}\right]\end{array}\right]\end{array}\right]$$

Notice that some of the equations in the f-description constrain the same attribute-value pairs. For example, the proper noun *Ram* requires its f-structure r to have an INDEX attribute specifying singular number (containing the attribute NUM with value SG):

(36) $(r\ \textsc{index num}) = \textsc{sg}$

The verb *calegaa* 'go' places the same requirement on its subject:

(37) $(c\ \textsc{subj index num}) = \textsc{sg}$

We also know that c's subject is r:

(38) $(c\ \textsc{subj}) = r$

Thus, the two equations in (36) and (37) both require the f-structure labeled r, which is also called (c SUBJ), to contain the attribute NUM with value SG in the INDEX feature bundle. It is common for an attribute and its value to be multiply constrained in this way; here, subject-verb agreement is enforced, since the NUM requirements of both the subject and the verb are satisfied.

We will not discuss particular methods or algorithms for solving systems of equations like the f-description in (34). Kaplan and Bresnan (1982) provide a particularly clear presentation of one algorithm for solving such sets of equations, and we briefly discuss some work on parsing and generation algorithms in Chapter 18, Section 3. There is a large body of work, summarized in detail by Rounds (1997), which explores the logic of feature structures and their descriptions. Some work in LFG and related frameworks discusses the operation of *unification*, first introduced in linguistic work by Kay (1979) (see also Shieber 1986). Unification is an operation (represented by $\sqcup$) that combines consistent feature structures into a new feature structure by taking the union of all the attribute-value pairs in the original structures. For instance, the unification of the two feature structures f and g in (39a) is the feature structure in (39b):

(39) a. $f\begin{bmatrix} \textsc{a} & \textsc{b} \\ \textsc{c} & \textsc{d} \end{bmatrix} \qquad g\begin{bmatrix} \textsc{c} & \textsc{d} \\ \textsc{e} & \begin{bmatrix} \textsc{f} & \textsc{g} \end{bmatrix} \end{bmatrix}$

b. $f \sqcup g\begin{bmatrix} \textsc{a} & \textsc{b} \\ \textsc{c} & \textsc{d} \\ \textsc{e} & \begin{bmatrix} \textsc{f} & \textsc{g} \end{bmatrix} \end{bmatrix}$

The operation of unification on feature structures is related in a clear way to the conjunction of constraints on those structures. Consider two f-descriptions F and G, and their minimal solutions, the feature structures f and g. If the two f-descriptions F and G are consistent and are taken to describe the same f-structure, then the minimal solution to the conjunction of the two f-descriptions $F \wedge G$ is exactly the unification of the two f-structures f and g.

2.2. Semantic Forms

2.2.1. Uniqueness

The value of the PRED attribute is called a *semantic form*. The difference between a semantic form and other atomic values is represented notationally by the presence of single quotes. Semantic forms behave in a special way in terms of the constraints described here: as discussed in Chapter 2, Section 4.2, the semantic form is instantiated to a *unique* value each time it appears in an f-description. For example, the name *David* is lexically associated with an equation like the one in (40), specifying its semantic form:

(40) $(f\ \textsc{pred}) = \text{`}\textsc{David}\text{'}$

Abstractly, a semantic form like ‘DAVID’ appearing in a lexical entry or phrase structure rule can be thought of as abbreviating an unbounded number of distinct forms with different indices (Kaplan and Bresnan 1982). For each use of a word or rule associated with the semantic form, a new and distinct indexed form is chosen. Thus, for example, a particular instance of use of the name *David* gives rise to an f-structure like the one in (41), where we have arbitrarily chosen the number 3 as the unique index:

(41) $$f\begin{bmatrix}\textsc{pred} & \text{`}\textsc{David}_3\text{'}\end{bmatrix}$$

This instantiated semantic form ‘$\textsc{David}_3$’ is distinct from the semantic form ‘$\textsc{David}_7$’ or ‘$\textsc{David}_{25}$’ for different instances of the use of *David*.

Recall the discussion in Chapter 2, Section 4 of f-structures in which two attributes have the same value:

(42) *David seemed to yawn.*

$$f\begin{bmatrix}\textsc{pred} & \text{`}\textsc{seem}\langle\textsc{xcomp}\rangle\textsc{subj}\text{'}\\ \textsc{subj} & \begin{bmatrix}\textsc{pred} & \text{`}\textsc{David}_3\text{'}\end{bmatrix}\\ \textsc{xcomp} & \begin{bmatrix}\textsc{pred} & \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'}\\ \textsc{subj} & \end{bmatrix}\end{bmatrix}$$

The verb *seem* requires its SUBJ to be the same as its XCOMP’s SUBJ by means of an equation like the following:

(43) $(f\ \textsc{subj}) = (f\ \textsc{xcomp}\ \textsc{subj})$

The value of the PRED attribute of the SUBJ ‘DAVID’ is instantiated to a unique value for this instance of its use. An equally correct but less succinct way of representing the same f-structure is:

(44) *David seemed to yawn.*

$$f\left[\begin{array}{ll}\text{PRED} & \text{`SEEM}\langle\text{XCOMP}\rangle\text{SUBJ'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`DAVID}_3\text{'}\end{array}\right] \\ \text{XCOMP} & \left[\begin{array}{ll}\text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`DAVID}_3\text{'}\end{array}\right]\end{array}\right]\end{array}\right]$$

Crucially, the indices on the semantic forms of the SUBJ and the XCOMP SUBJ f-structures are the same. The f-structure in (44) is *not* the same as the one in (45), in which two different semantic forms for *David* have distinct indices:

(45) Incorrect f-structure for *David seemed to yawn*:

$$\left[\begin{array}{ll}\text{PRED} & \text{`SEEM}\langle\text{XCOMP}\rangle\text{SUBJ'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`DAVID}_3\text{'}\end{array}\right] \\ \text{XCOMP} & \left[\begin{array}{ll}\text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`DAVID}_4\text{'}\end{array}\right]\end{array}\right]\end{array}\right]$$

Distinctness of semantic forms is important in enforcing Consistency (Chapter 2, Section 4.6.3). As discussed by Simpson (1991), word order in Warlpiri is very free; the subject may appear in any position in the sentence. However, even though subjects may appear in either sentence-initial or sentence-final position, a sentence with two subjects (one sentence-initial and one sentence-final) is ungrammatical (Simpson 1991, page 93):[5]

(46) **wati* *ka* *parnka-mi* *karnta*
man.ABS PRS run-NPST woman.ABS
'The man runs the woman.'

Intuitively, the sentence is unacceptable because of the simultaneous presence of two different subjects. In slightly more formal terms, the presence of two different semantic forms for the subject of the sentence causes a clash, and the resulting f-structure is ill-formed:

(47) Ill-formed f-structure:

$$\left[\begin{array}{ll}\text{PRED} & \text{`RUN}\langle\text{SUBJ}\rangle\text{'} \\ \text{TENSE} & \text{PRS} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`MAN'/`WOMAN'}\end{array}\right]\end{array}\right]$$

[5] In our discussion of Warlpiri in Chapter 4, we discussed example (32) (page 146) in which two separate phrases contributed to the SUBJ function. In that example, unlike (46), the two phrases are compatible and can both appear in the same utterance, since one phrase is interpreted as the head and the other is interpreted as a modifier of the head.

The clitic and full pronouns of Bosnian/Croatian/Serbian, as discussed by Franks and King (2000), provide further evidence for the behavior of semantic forms. For pronominal objects in Bosnian/Croatian/Serbian, a clitic pronoun (here, the third person singular feminine clitic *ju*) is generally used:[6]

(48) *Mirko ju je čitao.*
Mirko 3F.SG.ACC.CLITIC AUX.3SG.CLITIC read
'Mirko read it.'

Bosnian/Croatian/Serbian also has full pronominal forms (here, the third singular feminine pronoun *nju*), used for emphasis, which do not appear in the second-position clitic cluster:

(49) *Mirko je čitao nju.*
Mirko AUX.3SG.CLITIC read 3F.SG.ACC
'Mirko read it.'

The f-structures for these examples are fundamentally similar; (50) gives an abbreviated f-structure for both example (48) and example (49), with the OBJ f-structure labeled f:

(50)
$$\begin{bmatrix} \text{PRED} & \text{`READ}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`MIRKO'} \end{bmatrix} \\ \text{OBJ} & f\begin{bmatrix} \text{PRED} & \text{`PRO'} \\ \text{INDEX} & \begin{bmatrix} \text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{GEND} & \text{F} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The lexical entries for the clitic and full pronoun contain the information in (51):

(51) *ju*
$(f \text{ PRED}) = \text{`PRO'}$
$(f \text{ INDEX PERS}) = 3$
$(f \text{ INDEX NUM}) = \text{SG}$
$(f \text{ INDEX GEND}) = \text{F}$

nju
$(f \text{ PRED}) = \text{`PRO'}$
$(f \text{ INDEX PERS}) = 3$
$(f \text{ INDEX NUM}) = \text{SG}$
$(f \text{ INDEX GEND}) = \text{F}$

In Bosnian/Croatian/Serbian, the clitic pronoun and the full pronoun cannot be used in the same sentence:

(52) **Mirko ju je čitao nju.*
Mirko 3F.SG.ACC.CLITIC AUX.3SG.CLITIC read 3F.SG.ACC

[6]Following Franks and King, we translate the feminine full and clitic pronouns *nju* and *ju* as 'it' when they appear as the object of the verb *čitao* 'read'.

‘Mirko read it it.’

Despite the fact that the PRED value contributed by both pronominal forms is ‘PRO’, the sentence is ungrammatical; again, as above, a clash is produced by multiple specification of semantic forms with different indices as the value of the OBJ PRED:[7]

(53) Ill-formed f-structure:

$$
\left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{read}\langle\textsc{subj},\textsc{obj}\rangle\text{’} \\
\textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{‘Mirko’}\end{array}\right] \\
\textsc{obj} & f\left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{pro}_1\text{’/‘}\textsc{pro}_2\text{’} \\ \textsc{index} & \left[\begin{array}{ll}\textsc{pers} & 3 \\ \textsc{num} & \textsc{sg} \\ \textsc{gend} & \textsc{f}\end{array}\right]\end{array}\right]
\end{array}\right]
$$

In general, following standard LFG practice, we will not display indices on semantic forms unless it is necessary for clarity, and two different semantic forms are treated as distinct even if they look the same. If we want to indicate that the same semantic form appears in two different places in the f-structure, as in example (42), we will draw a line connecting the two occurrences.

In some cases, the value of an attribute other than PRED might be required to be uniquely contributed; for instance, the value of the TENSE attribute is contributed by only a single form, and multiple contributions are disallowed:

(54) a. *Is David yawning?*
b. **Is David is yawning?*
c. **Is David yawns?*

An *instantiated symbol* can be used as the value of the TENSE attribute in such a situation. Like a semantic form, an instantiated symbol takes on a unique value on each occasion of its use. In general, any syntactic uniqueness requirement for an attribute can be imposed by the use of an instantiated symbol as the value of that attribute. Notationally, instantiated symbols are followed by an underscore; for example, to indicate that the value for the attribute TENSE is the instantiated symbol PRS, we write:

(55) $(f\ \textsc{tense}) = \textsc{prs}\_$

2.2.2. Argument Lists

A semantic form, unlike other values, may contain an argument list. In example (50) of this chapter, the PRED value contributed by the verb *čitao* ‘read’ is the

[7] In contrast to Bosnian/Croatian/Serbian, clitic doubling is possible in certain dialects of Spanish, as discussed in Chapter 4, Section 3.2, as well as other Slavic languages. This is because the PRED value of the clitic pronoun in these languages is *optional*, as we will see in Section 2.4 of this chapter.

complex semantic form 'READ⟨SUBJ,OBJ⟩'. As discussed in Chapter 2, Section 4.6, this f-structure is *complete* and *coherent* because the requirements specified by the semantic form for *čitao* 'read' are satisfied: the f-structure has a SUBJ and an OBJ, and there are no other governable grammatical functions in the f-structure that are not mentioned in the argument list of *čitao* 'read'. Additionally, since the SUBJ and OBJ arguments of *čitao* 'read' are semantic arguments appearing inside the angled brackets of the argument list, each must contain a PRED; nonsemantic arguments mentioned outside the angled brackets in the argument list must also be present in the f-structure, but are not required to contain a PRED.

2.2.3. Reference to Parts of the Semantic Form

It is possible to use a special set of attributes to refer to parts of a semantic form. For a simple semantic form like 'David', the attribute FN can be used to refer to the function component:

(56) If (f PRED) = 'David', then:

(f PRED FN) = David

Numbered attributes such as ARG1 and ARG2 can be used to refer to the arguments of the semantic form. For example, given the semantic form 'READ⟨SUBJ,OBJ⟩', the following equations hold:

(57) If (f PRED) = 'READ⟨SUBJ,OBJ⟩', then:

(f PRED FN) = READ
(f PRED ARG1) = SUBJ
(f PRED ARG2) = OBJ

Nonthematic arguments appearing outside the angled brackets are referred to by numbered attributes such as NOTARG1 and NOTARG2:

(58) If (f PRED) = 'SEEM⟨XCOMP⟩SUBJ', then:

(f PRED FN) = SEEM
(f PRED ARG1) = XCOMP
(f PRED NOTARG1) = SUBJ

More generally, for some semantic form p:

- (p FN) is the function component;
- (p ARG1) is the first argument inside the angled brackets in the argument list, and (p ARGn) is the nth argument inside the angled brackets in the argument list;
- (p NOTARG1) is the first nonthematic argument outside the angled brackets in the argument list, and (p NOTARGn) is the nth nonthematic argument outside the angled brackets.

2.3. Disjunction

An f-description can also consist of a *disjunction* of two or more descriptions. When this happens, one of the disjuncts must be satisfied for the f-description to hold.

For instance, the form *met* of the English verb *meet* is either a past tense form or a past participle:

(59) *I met/have met him.*

This is reflected in the following disjunctive f-description in the lexical entry for *met*, which says that the f-structure f for *met* must contain either the attribute-value pair $\langle$TENSE, PST$\rangle$ or the attribute-value pair $\langle$VTYPE, PST.PTCP$\rangle$:

(60) *met* $(f\ \text{PRED}) = \text{`MEET}\langle\text{SUBJ,OBJ}\rangle\text{'}$
$\{(f\ \text{TENSE}) = \text{PST} \mid (f\ \text{VTYPE}) = \text{PST.PTCP}\}$

There are two minimal solutions to this f-description:

(61) a. $f\begin{bmatrix} \text{PRED} & \text{`MEET}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{TENSE} & \text{PST} \end{bmatrix}$

b. $f\begin{bmatrix} \text{PRED} & \text{`MEET}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{VTYPE} & \text{PST.PTCP} \end{bmatrix}$

Each of these minimal solutions satisfies one of the disjuncts of the description.

Formally, a disjunction over descriptions is satisfied when one of the disjuncts is satisfied:

(62) Disjunction:

A disjunction $\{d_1 \mid \ldots \mid d_n\}$ over f-descriptions $d_1 \ldots d_n$ holds of an f-structure f if and only if there is some disjunct d_k, $1 \leq k \leq n$, that holds of f.

2.4. Optionality

An f-description can also be *optional*. When this happens, the f-description may but need not be satisfied.

Bresnan and Mchombo (1987) show that verbs in Chicheŵa optionally carry information about their subjects; in a Chicheŵa sentence, a subject noun phrase may be either present (63a) or absent (63b):

(63) a. *njûchi zi-ná-lúm-a alenje*
bees 10SUBJ-PST-bite-IND hunters
'The bees bit the hunters.'

b. *zi-ná-lúm-a alenje*
10SUBJ-PST-bite-IND hunters
'They bit the hunters.'

Bresnan and Mchombo propose that the verb *zi-ná-lúm-a* 'bit' optionally contributes an f-description constraining the value of the PRED attribute of its subject. This optional f-description is enclosed in parentheses:

(64) *zi-ná-lúm-a:* $((f\ \text{SUBJ PRED}) = \text{'PRO'})$

Since the equation $(f\ \text{SUBJ PRED}) = \text{'PRO'}$ is optional, it may but need not contribute to the minimal solution to the f-description for the sentence. If an overt subject noun phrase does not contribute its own PRED value, the f-structure for the sentence is incomplete unless this equation is satisfied, and in this case the well-formed f-structure for the SUBJ contains the pair ⟨PRED, 'PRO'⟩. If an overt subject noun phrase appears, the equation cannot be satisfied, since the PRED value of the overt subject would produce a clash; instead, the PRED value for the SUBJ is the one specified by the subject noun phrase:

(65) a. *njûchi zi-ná-lúm-a alenje*
bees 10SUBJ-PST-bite-IND hunters
'The bees bit the hunters.'

$$f\left[\begin{array}{ll} \text{PRED} & \text{'BITE}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{'BEE'} \\ \text{NOUNCLASS} & 10 \end{array}\right] \\ \text{OBJ} & \left[\begin{array}{ll} \text{PRED} & \text{'HUNTER'} \\ \text{NOUNCLASS} & 2 \end{array}\right] \end{array}\right]$$

b. *zi-ná-lúm-a alenje*
10SUBJ-PST-bite-IND hunters
'They bit the hunters.'

$$f\left[\begin{array}{ll} \text{PRED} & \text{'BITE}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{'PRO'} \\ \text{NOUNCLASS} & 10 \end{array}\right] \\ \text{OBJ} & \left[\begin{array}{ll} \text{PRED} & \text{'HUNTER'} \\ \text{NOUNCLASS} & 2 \end{array}\right] \end{array}\right]$$

A similar analysis is appropriate for languages that allow *clitic doubling*. As discussed in Chapter 4, Section 3, the River Plate and Peruvian dialects of Spanish allow either a clitic or a full noun phrase object to appear:

(66) a. *Juan vió a Pedro.*
Juan saw PREP Pedro
'Juan saw Pedro.'

b. *Juan lo vió.*
Juan 3SG.ACC.CLITIC saw
'Juan saw him.'

Unlike many other dialects of Spanish, in these dialects the clitic pronoun can co-occur with a full noun phrase object:

(67)	*Juan*	*lo*	*vió*	*a*	*Pedro.*
	Juan	3sg.acc.clitic	saw	prep	Pedro
	'Juan saw Pedro.'				

We account for these facts by assuming that in the River Plate and Peruvian dialects, the pred value contributed by the clitic pronoun *lo* is optional:

(68) *Pedro* $(f\ \textsc{pred}) = \text{`}\textsc{Pedro}\text{'}$

lo $((f\ \textsc{pred}) = \text{`}\textsc{pro}\text{'})$

A skeletal f-structure for (66a) and (67) is:

(69)
$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{see}\langle\textsc{subj},\textsc{obj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix}\textsc{pred} & \text{`}\textsc{Juan}\text{'}\end{bmatrix} \\ \textsc{obj} & f\begin{bmatrix}\textsc{pred} & \text{`}\textsc{Pedro}\text{'}\end{bmatrix}\end{bmatrix}$$

When a full noun phrase object is present, the optional equation contributing the pred value of the clitic pronoun is not satisfied; if two preds were present, the example would not satisfy Consistency. When there is no full noun phrase, in order to satisfy Completeness, the pred contributed by the clitic noun phrase appears. The f-structure for example (66b) is given in (70):

(70)
$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{see}\langle\textsc{subj},\textsc{obj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix}\textsc{pred} & \text{`}\textsc{Juan}\text{'}\end{bmatrix} \\ \textsc{obj} & f\begin{bmatrix}\textsc{pred} & \text{`}\textsc{pro}\text{'}\end{bmatrix}\end{bmatrix}$$

Formally, optionality of an f-description *d* is treated like a disjunction between *d* and the f-description *true*, a statement that is always true.

(71) Optionality:

An f-description *d* optionally holds of an f-structure f if and only if the disjunction $\{d \mid true\}$ holds of f.

2.5. Negation

An f-description can be *negated*; when this happens, the f-description must not be satisfied. Notationally, negation of a single equation is indicated by a diagonal line through the equals sign: $f \neq g$ means that f does not equal g.

For example, as discussed in Chapter 2, Section 5.3, Quirk et al. (1972, 15.6) claim that it is not possible to use the complementizer *if* in the clausal complement of certain verbs, including the verb *justify*:

(72) a. *I know whether/if David yawned.*

b. *You have to justify whether/*if your journey is really necessary.*

We can analyze the verb *justify* as described by Quirk et al. differently from a verb like *know* by prohibiting the value IF for the attribute COMPFORM in its COMP argument:

(73) *justify* $(f\ \textsc{comp}\ \textsc{compform}) \neq \textsc{if}$

The f-structure in (74) satisfies this constraint:

(74) *Chris justified whether David deserved the prize.*

$$f\left[\begin{array}{ll} \textsc{pred} & \text{'}\textsc{justify}\langle\textsc{subj,comp}\rangle\text{'} \\ \textsc{subj} & \left[\begin{array}{ll} \textsc{pred} & \text{'Chris'} \end{array}\right] \\ \textsc{comp} & \left[\begin{array}{ll} \textsc{pred} & \text{'}\textsc{deserve}\langle\textsc{subj,obj}\rangle\text{'} \\ \textsc{compform} & \textsc{whether} \\ \textsc{tense} & \textsc{pst} \\ \textsc{subj} & \left[\begin{array}{ll} \textsc{pred} & \text{'David'} \end{array}\right] \\ \textsc{obj} & \left[\begin{array}{ll} \textsc{pred} & \text{'}\textsc{prize}\text{'} \\ \textsc{def} & + \end{array}\right] \end{array}\right] \end{array}\right]$$

However, the f-structure in (75) does not satisfy the constraint; the offending value is circled:

(75) **Chris justified if David deserved the prize.*

$$f\left[\begin{array}{ll} \textsc{pred} & \text{'}\textsc{justify}\langle\textsc{subj,comp}\rangle\text{'} \\ \textsc{subj} & \left[\begin{array}{ll} \textsc{pred} & \text{'Chris'} \end{array}\right] \\ \textsc{comp} & \left[\begin{array}{ll} \textsc{pred} & \text{'}\textsc{deserve}\langle\textsc{subj,obj}\rangle\text{'} \\ \textsc{compform} & \textsc{if} \\ \textsc{tense} & \textsc{pst} \\ \textsc{subj} & \left[\begin{array}{ll} \textsc{pred} & \text{'David'} \end{array}\right] \\ \textsc{obj} & \left[\begin{array}{ll} \textsc{pred} & \text{'}\textsc{prize}\text{'} \\ \textsc{def} & + \end{array}\right] \end{array}\right] \end{array}\right]$$

This example shows that a single equation can be negated, requiring a particular attribute-value pair not to appear. More generally, it is possible to negate not just a single equation, but an entire f-description. The following expressions are notationally equivalent:

(76) $(f\ a) \neq v \ \equiv\ \neg[(f\ a) = v]$

The negation of a conjunction of descriptions holds just in case at least one of the descriptions does not hold. For example, the base form for verbs in English also serves as the present tense form for all person/number combinations except third person singular: *I/you/*he/we/they yawn*. We might analyze this by means of a constraint like the one in (77), which states that the INDEX f-structure f for the subject of a bare verb must not contain both $\langle \text{PERS}, 3\rangle$ and $\langle \text{NUM}, \text{SG}\rangle$:

(77) $$\neg[(f\ \text{PERS}) = 3 \\ (f\ \text{NUM}) = \text{SG}]$$

Formally, negation of f-descriptions is defined in the following way:

(78) Negation:

A negated f-description $\neg d$ holds of an f-structure f if and only if the description d does not hold of f.

2.6. Existential Constraints

An f-structure may be required to contain an attribute, but its value may be unconstrained: this kind of constraint is called an *existential constraint*. The f-structural requirement of *Completeness* (Chapter 2, Section 4.6.1) is a kind of existential constraint: Completeness requires the presence of all of the governable grammatical functions specified by a predicate, but does not place any constraints on the particular values of these functions.

Existential constraints can be used in the analysis of relative clauses. The English relative clause must be tensed, but no particular value for the tense attribute is required:

(79) a. *the man who yawned*
b. *the man who yawns*
c. *the man who will yawn*
d. **the man who yawning*

The f-structure for example (79a) is shown in (80). Note that the f-structure labeled f contains the attribute TENSE with value PST:

(80) *the man who yawned*

$$\left[\begin{array}{ll} \text{PRED} & \text{`MAN'} \\ \text{DEF} & + \\ \text{ADJ} & \left\{ f\left[\begin{array}{ll} \text{DIS} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\\ \text{PRONTYPE} & \text{REL}\end{array}\right]\right\} \\ \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{TENSE} & \text{PST} \\ \text{SUBJ} & \end{array}\right]\right\} \end{array}\right]$$

We can enforce the requirement for relative clauses to be tensed by means of a constraint like the following:

(81) $(f\ \textsc{tense})$

This constraint requires the f-structure f to contain the attribute TENSE, but it does not constrain the value of the TENSE attribute; any value is acceptable. The f-structure in (80) satisfies this constraint. However, an f-structure like the one in (82) does not satisfy the constraint, since it has no TENSE attribute:

(82) **the man who yawning*

$$\begin{bmatrix} \text{PRED} & \text{`MAN'} \\ \text{DEF} & + \\ \text{ADJ} & \left\{ f\begin{bmatrix} \text{DIS} & \left\{\begin{bmatrix}\text{PRED} & \text{`PRO'}\\ \text{PRONTYPE} & \text{REL}\end{bmatrix}\right\} \\ \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{VTYPE} & \text{PRS.PTCP} \\ \text{SUBJ} & \end{bmatrix} \right\} \end{bmatrix}$$

Formally, an existential constraint has the following interpretation:

(83) Existential constraint:

The existential constraint $(f\ a)$ holds of an f-structure f if and only if there is some value v for which the pair $\langle a, v\rangle \in f$.

2.7. Negative Existential Constraints

Just as an f-structure can be required to contain some attribute, it can be prohibited from containing some attribute: this is a *negative existential constraint*. The f-structural requirement of *Coherence* is a constraint of this kind (Chapter 2, Section 4.6.2): a grammatical function that is not mentioned in the argument list of the PRED must not appear in the f-structure.

Another use of a negative existential constraint is in the analysis of participial modifiers, as discussed by Bresnan (1982a). Such modifiers must not be tensed:

(84) a. *Scratching his head, Chris yawned.*

b. *Struck on the head, Chris slumped to the floor.*

c. **Scratched/Scratches his head, Chris yawned.*

This constraint can be expressed in the following way:

(85) $\neg(f\ \textsc{tense})$

The constraint in (85) ensures that the f-structure f has no TENSE attribute. The constraint is satisfied in (86):

(86) *Scratching his head, Chris yawned.*

$$
\left[\begin{array}{ll}
\textsc{pred} & \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'} \\
\textsc{tense} & \textsc{pst} \\
\textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{`Chris'}\end{array}\right] \\
\textsc{xadj} & \left\{ f \left[\begin{array}{ll}
\textsc{subj} & \\
\textsc{pred} & \text{`}\textsc{scratch}\langle\textsc{subj,obj}\rangle\text{'} \\
\textsc{vtype} & \textsc{prs.ptcp} \\
\textsc{obj} & \left[\begin{array}{ll}
\textsc{pred} & \text{`}\textsc{head}\text{'} \\
\textsc{poss} & \left[\begin{array}{ll}
\textsc{pred} & \text{`}\textsc{pro}\text{'} \\
\textsc{index} & \left[\begin{array}{ll}
\textsc{pers} & 3 \\
\textsc{num} & \textsc{sg} \\
\textsc{gend} & \textsc{m}
\end{array}\right]
\end{array}\right]
\end{array}\right]
\end{array}\right] \right\}
\end{array}\right]
$$

Formally, a negative existential constraint is interpreted in the following way:

(87) Negative existential constraint:

The negative existential constraint $\neg(f\ a)$ holds of an f-structure f if and only if there is no value v for which the pair $\langle a, v\rangle \in f$.

2.8. Defining and Constraining Equations

Besides defining equations like $(f\ a) = v$, LFG allows *constraining equations*, which contribute in a different way to the solution: defining equations determine the minimal solution, and constraining equations check that the minimal solution is wellformed. An example will help to show the difference between the two kinds of equations.

In English, a clausal argument need not contain the complementizer *that* when it bears the grammatical function COMP, but it must contain *that* when it is a SUBJ:

(88) a. *Chris thought [that David yawned].*

b. *Chris thought [David yawned].*

c. *[That David yawned] surprised Chris.*

d. **[David yawned] surprised Chris.*

We assume that the lexical entry for the complementizer *that* contributes the following defining equation:

(89) $(f\ \textsc{compform}) = \textsc{that}$

In (88c), the clausal argument *that David yawned* is the SUBJ of the clause, and contains the attribute-value pair $\langle\textsc{compform}, \textsc{that}\rangle$:

(90) *That David yawned surprised Chris.*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{surprise}\langle\textsc{subj},\textsc{obj}\rangle\text{'} \\ \textsc{tense} & \textsc{pst} \\ \textsc{subj} & f\begin{bmatrix} \textsc{pred} & \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'} \\ \textsc{tense} & \textsc{pst} \\ \textsc{compform} & \textsc{that} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`David'} \end{bmatrix} \end{bmatrix} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{`Chris'} \end{bmatrix} \end{bmatrix}$$

The defining equation in (89) is satisfied, because the f-structure labeled f has an attribute COMPFORM with value THAT. Hence, (90) is an acceptable minimal solution to an f-description that includes the defining equation in (89).

In contrast, the pair ⟨COMPFORM, THAT⟩ is not required to belong to the f-structure of a COMP; example (88b) is grammatical, and its f-structure is wellformed:

(91) *Chris thought David yawned.*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{think}\langle\textsc{subj},\textsc{comp}\rangle\text{'} \\ \textsc{tense} & \textsc{pst} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`Chris'} \end{bmatrix} \\ \textsc{comp} & f\begin{bmatrix} \textsc{pred} & \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'} \\ \textsc{tense} & \textsc{pst} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`David'} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The equation in (89) is not a part of the f-description for example (88b), since the word *that* does not appear; in the minimal solution to the f-description for this sentence, f does not have an attribute COMPFORM with any value.

Our task, then, is to require a clausal subject such as the one in (90) to contain the attribute COMPFORM with value THAT, and thus to ensure the presence of the complementizer *that*. To impose this requirement, we can use the *constraining equation* in (92):

(92) $(f\ \textsc{compform}) =_c \textsc{that}$

Notationally, a constraining equation differs from a defining equation by the presence of the subscript c on the equals sign. A constraining equation is not used in determining the minimal solution to an f-description. Instead, it imposes an additional requirement on the minimal solution obtained from the defining equations in the f-description: it requires the pair ⟨COMPFORM, THAT⟩ to be in the minimal solution for f, as is the case in (90). Some other defining equation must specify this attribute-value pair for the final solution to be acceptable.

The constraining equation in (92) holds of the f-structure in (90), since the f-structure labeled f contains the pair <COMPFORM,THAT>. It does not hold of the f-structure in (91). It is only when the complementizer *that* contributes the defining equation in (89) that the constraining equation in (92) can be satisfied. Notice in particular that we cannot impose a requirement for the presence of *that* via a defining equation. Introducing an additional defining equation like (f COMPFORM) = THAT would just ensure that the attribute COMPFORM with its value THAT is a part of the minimal solution for f, no matter whether the word *that* is present in the sentence or not.

We can also use constraining equations to encode requirements on semantic forms which would otherwise be impossible to state. Recall from Section 2.2 that each use of a semantic form is instantiated to a unique value: we cannot require the object of an f-structure f to be pronominal by introducing an equation like the one in (93), since such an equation would introduce a unique semantic form value for the PRED of the OBJ which is incompatible with any other semantic form introduced by another equation:

(93) Introducing the semantic form ‘PRO’ as the value of the OBJ’s PRED:

(f OBJ PRED) = ‘PRO’

Instead, we can require an object to be pronominal by requiring its PRED FN to be PRO. The constraining equation in (94) holds of all semantic forms contributed by equations like the one in (93) (see Section 2.2.3 for an explanation of the attribute FN):

(94) Requiring the OBJ to be pronominal:

(f OBJ PRED FN) $=_c$ PRO

We can propose a formal definition for constraining equations, following Kaplan and Bresnan (1982):

(95) Constraining equation:

(f a) $=_c$ v holds if and only if f is an f-structure, a is a symbol, and the pair $\langle a, v \rangle$ is in the minimal solution for the defining equations in the f-description of f.

Kaplan and Bresnan (1982) provide an interesting discussion of the formal role of constraining equations and existential constraints in LFG (see also Johnson 1999; Saraswat 1999). As they note, constraining equations and existential constraints are particularly useful when the presence of a feature is associated with a marked value for the feature, with the absence of the feature indicating the unmarked value (Chapter 2, Section 5.2). For instance, all marked forms of a particular paradigm may be associated with a certain feature: assume, for instance, that only passive verbs have a value PASS for the VOICE feature, and active verbs have no VOICE feature. In this situation, if a particular voice of a verb is required, a constraining equation must be used to check for the presence or absence of the VOICE feature; a defining equation mentioning the VOICE feature would be compatible with passive verb forms as well as with active forms unspecified for the VOICE feature, the wrong result.

In certain limited situations, the use of a defining equation does not produce a different result from the use of a constraining equation. A constraining equation is used to check whether an attribute and its value are present in the minimal solution of an f-description. If we know that a particular attribute is always present in a certain type of f-structure, we need not use a constraining equation to check its value: in that situation, using a defining equation produces the same result. For instance, suppose that all noun phrases in English are marked for number, so that they are all either singular or plural. Suppose further that the value for the number feature is not an instantiated symbol and can be specified by more than one defining equation. Then, in specifying number agreement with a noun phrase, it does not matter whether the specification involves a defining equation or a constraining equation: we know that the minimal solution to the constraints always contains a number attribute with some value, since all noun phrases are specified for number. We can include an additional defining specification of the feature, or we can use a constraining equation to ensure that the feature and its required value are present in the minimal f-structure satisfying the defining equations.

2.9. Feature Defaults

Some features can be treated as having default values which can be overridden by the specification of a non-default value. Let us assume, for example, that we would like to treat the attribute CASE as having the default value NOM; we can accomplish this by means of the following disjunctive specification:[8]

(96) The attribute CASE has the default value NOM:

$$\left\{ \begin{array}{c|c} (f\ \textsc{case}) & (f\ \textsc{case}) = \textsc{nom} \\ (f\ \textsc{case}) \neq \textsc{nom} & \end{array} \right\}$$

According to this disjunctive constraint, one of two alternative descriptions must hold of an f-structure f:

- The existential constraint (f CASE) holds: f has a CASE attribute; furthermore, the value of (f CASE) is not the default value NOM; or

- f has an attribute CASE whose value is (perhaps redundantly) specified as the default value NOM.

If this constraint is present, the f-structure f must have some value for the attribute CASE. Some other component of the grammar may specify a non-default value (a value other than NOM) for CASE. If there is no other specification of a different value for CASE elsewhere in the full f-description, then the value of the CASE attribute for f is the default, NOM.

[8]Disjunction is discussed in Section 2.3, negation is discussed in Section 2.5, and existential constraints are discussed in Section 2.6.

Some works adopt a simpler treatment of defaults:

(97) The attribute CASE has the default value NOM, alternative (simpler) specification:

$$\left\{ (f \text{ CASE}) \mid (f \text{ CASE}) = \text{NOM} \right\}$$

According to this simple specification, there are two possibilities:

- The existential constraint (f CASE) holds: a value for CASE is specified by some component of the grammar; or
- the value for CASE is the default value, NOM.

This simpler statement has the same effect as the more complex one in (96), in that it specifies a default value NOM for the attribute CASE. However, it is less constrained, in that it allows more than one equivalent way of satisfying a default specification in some circumstances. If another component of the full f-description specifies the default value NOM for the CASE attribute, both alternatives in (97) are satisfied: (i) there is a value for the CASE attribute, and (ii) it is the default value, NOM. This means that there may be more than one solution for an f-description with this simpler form of default specification, giving rise to the appearance of ambiguity where no ambiguity exists. Thus, we prefer the more complex statement of defaults as in (96), since it does not permit both alternatives to be satisfied at the same time.

The general form of default specifications is, then, as follows:

(98) The attribute a has the default value v:

$$\left\{ \begin{array}{c} (f\ a) \\ (f\ a) \neq v \end{array} \middle| \begin{array}{c} (f\ a) = v \\ \end{array} \right\}$$

It is important for default specifications to interact in the desired way with specifications of feature values in other components of the grammar. Grammars appealing to default specifications must use defining equations to specify a non-default value for a feature, and constraining equations must be used to check the value of a default feature in circumstances where a non-default value should not be imposed (for more discussion of defining and constraining equations, see Section 2.8).

2.10. Implication

It is often convenient and intuitive to express a linguistic generalization as an implication. For example, implicational constraints can be used to encode effects of the person hierarchy in Lummi transitive sentences. Building on work by Jelinek and Demers (1983), Bresnan et al. (2001) observe that Lummi requires the person hierarchy in (99a) to be aligned with the grammatical function hierarchy, with the result that a first or second person argument cannot be lower than a third person argument on the grammatical function hierarchy.

(99) a. Person hierarchy in Lummi: 1, 2 > 3
b. Grammatical function hierarchy: SUBJ> OBJ> OBL

This means that a third-person subject may not appear with a first or second person object in an active Lummi sentence, and in a passive sentence, a third person subject may not appear with a first or second person oblique argument.[9] Jelinek and Demers (1983) provide the data in (100-101) to illustrate these patterns.[10] In the active sentences in (100), a third person subject may not appear with a first or second person object, as in (100c), but other combinations are allowed:

(100) Active sentences:

a. *x̣či-t sən cə swəyʔqəʔ*
know-ACTIVE 1NOM the man
'I know the man'. 1SUBJ, 3OBJ

b. *x̣či-t-sx^w cə swəyʔqəʔ*
know-ACTIVE-2NOM the man
'You know the man.' 2SUBJ, 3OBJ

c. *'The man knows me/you.' *3SUBJ, 1/2OBJ

d. *x̣či-t-s cə swəyʔqəʔ cə swiʔqoʔəɬ*
know-ACTIVE-3 the man the boy
'The man knows the boy.' 3SUBJ, 3OBJ

In the passive sentences in (101), a third person subject may not appear with a first or second person oblique phrase, as in (101c), but other combinations are allowed:

(101) Passive sentences:

a. *x̣či-tŋ-sən cə swəyʔqəʔ*
know-PASS-1NOM the man
'I am known by the man.' 1SUBJ, 3OBL

b. *x̣či-tŋ-sx^w cə swəyʔqəʔ*
know-PASS-2NOM the man
'You are known by the man.' 2SUBJ, 3OBL

c. *'The man is known by me/you.' *3SUBJ, 1/2OBL

d. *x̣či-tŋ cə swiʔqoʔəɬ cə swəyʔqəʔ*
know-PASS the boy the man
'The boy is known by the man.' 3SUBJ, 3OBL

Thus, we would like a way of formally stating the generalization in (102):

(102) In Lummi, if the subject is third person, the object or oblique phrase cannot be first or second person.

[9]Constraints on voice and the person hierarchy in Lummi are more complicated than the data in this section indicate; for a detailed discussion, see Jelinek and Demers (1983).

[10]Jelinek and Demers do not provide Lummi equivalents for the ungrammatical patterns.

An implication is written with the double right arrow "⇒". For any clausal f-structure f in Lummi, the following implication holds:[11]

(103) If f's subject is third person, its object or oblique is not first or second person:

$$(f \textsc{ subj index pers}) = 3 \;\Rightarrow\; \begin{array}{l}(f \; \{\textsc{obj}|\textsc{obl}\} \textsc{ index pers}) \neq 1 \\ (f \; \{\textsc{obj}|\textsc{obl}\} \textsc{ index pers}) \neq 2\end{array}$$

Since negation and disjunction are permitted in f-descriptions, we can define the implication relation by using negation and disjunction. In the general case, the implication in (104a) can be paraphrased as in (104b):[12]

(104) a. $d1 \;\Rightarrow\; d2$ ("$d1$ implies $d2$" or "if $d1$ holds, then $d2$")

b. "either $d1$ does not hold, or $d1$ holds and we can introduce the f-description $d2$"

As the paraphrase in (104b) indicates, $d1$ in the implicational statement in (104a) has the status of a constraining equation: we first check the minimal solution for the rest of the f-description of an utterance to see if $d1$ holds, and if it does, we augment the f-description for the utterance with $d2$.

We can give any f-description the status of a constraining equation by negating it twice: $\neg\neg d1$ ("it is not the case that $d1$ is false"). Twice negated, $d1$ must hold of the minimal solution for the rest of the f-description, but it does not have the status of a defining equation. We can now define the implication relation for f-descriptions:

(105) Implication:

Given two f-descriptions $d1$ and $d2$, $d1 \;\Rightarrow\; d2$ ("$d1$ implies $d2$") holds if and only if $\{\neg d1 \mid \neg\neg d1, d2\}$ ("either $d1$ does not hold, or it is not the case that $d1$ does not hold, and $d2$ holds").

Bresnan et al. (2016, page 61) provide more discussion of implicational constraints.

[11] For simplicity, we assume that the value of the PERS feature is one of the atomic values 1, 2, or 3. The complex person features discussed in Chapter 2, Section 5.7.2 do not provide a means of referring to first and second person as a natural class of feature values, to the exclusion of third person; further refinement to the values proposed for the PERS feature by Otoguro (2015) would allow us to simplify the rule in (103) by referring to such a class.

[12] Formally, this equivalence is motivated by the conditional law, which states that the implication $d1 \rightarrow d2$ holds if and only if either $d1$ fails to hold, or $d2$ holds:

$$[d1 \rightarrow d2] \Leftrightarrow \{\neg d1 \mid d2\}$$

Since either an f-description $d1$ or its negation $\neg d1$ is true of any f-structure, we can use the stronger formulation of equality in (104).

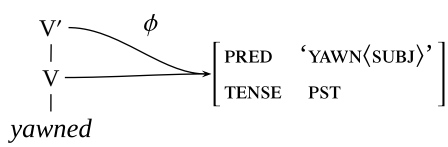
3. THE C-STRUCTURE/F-STRUCTURE CORRESPONDENCE

3.1. Annotated Phrase Structure Rules

Chapter 4 discussed universally valid correspondences between c-structure and f-structure: a c-structure head and the phrases it projects correspond to the same f-structure, for example. Here we show how these correspondences are formally stated.

Recall that the ϕ function defines a relation between c-structure nodes and f-structures:

(106)



To make the following discussion simpler, we assume that the rule expanding V′ is:

(107) $\text{V}' \quad \longrightarrow \quad \text{V}$

As discussed in Chapter 4, Section 2.1, a phrase and its head correspond to the same f-structure. Here, V is the head of V′, and so V′ and V correspond to the same f-structure. We would like a way to express this fact.

We accomplish this by annotating the V node with an expression requiring the f-structure of the V to be the same as the f-structure for the V′. In general, any daughter node — that is, any node on the right-hand side of a phrase structure rule — may be annotated with constraints on the relation between its f-structure and the f-structure of the mother node. If the daughter node is the head, the f-structures must be the same. If the daughter node is a nonhead, its f-structure bears some relation (say, the OBJ relation) in the mother's f-structure.

In order to do this, we need a notation for the following concepts:

(108)

the current c-structure node ("self"):	$*$
the immediately dominating node ("mother"):	$\hat{*}$
the c-structure to f-structure function:	ϕ

The symbol $*$ stands for the node corresponding to the rule element on which the constraint is written; note that this use of $*$ is not related to the Kleene star notation indicating that a category or attribute can be repeated zero or more times, as discussed in Section 1.1 of this chapter. The symbol $\hat{*}$ stands for the node immediately dominating the $*$ node. In some LFG literature, the immediately dominating node $\hat{*}$ is represented by means of the mother function $\mathcal{M}$, as $\mathcal{M}(*)$; the two expressions $\hat{*}$ and $\mathcal{M}(*)$ are equivalent.

The function ϕ applies to a c-structure node to give the f-structure corresponding to that node. Thus, $\phi(*)$ is the f-structure corresponding to the current node, and $\phi(\hat{*})$ is the f-structure corresponding to the mother node in a rule.

To indicate that the f-structure for the V′ is the same as the f-structure for the V in the rule given in (107), we can write:

(109) $$\mathrm{V}' \longrightarrow \begin{array}{c} \mathrm{V} \\ \phi(\hat{*}) = \phi(*) \\ \text{mother's (V′'s) f-structure = self's (V's) f-structure} \end{array}$$

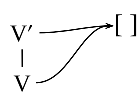
A convenient abbreviation is usually used for $\phi(\hat{*})$ and $\phi(*)$:

(110)
$\phi(\hat{*})$ (mother's f-structure) $= \uparrow$
$\phi(*)$ (self's f-structure) $= \downarrow$

The intuition behind this notation comes from the way trees are usually represented: the up arrow $\uparrow$ points to the mother node, while $\downarrow$ points to the node itself. Using these abbreviations, we can rewrite the rule in (109) in the following more standard way:

(111) $$\mathrm{V}' \longrightarrow \begin{array}{c} \mathrm{V} \\ \uparrow = \downarrow \\ \text{mother's f-structure = self's f-structure} \end{array}$$

This rule represents the following configuration:

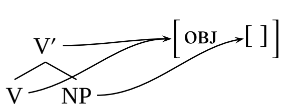
(112)


In some LFG literature, f-structure annotations are written above the node labels of a constituent structure tree, making the intuition behind the $\uparrow$ and $\downarrow$ notation clearer; written this way, the arrows point to the appropriate phrase structure nodes:

(113)
$$\begin{array}{c} \mathrm{V}' \\ | \\ \uparrow = \downarrow \\ \mathrm{V} \end{array}$$

In the following, we will stick to the more common practice of writing functional annotations beneath the node label in the phrase structure rule, as in (111).

Let us turn to a slightly more complicated rule, one that describes the following c-structure and f-structure:

(114)


Here, the NP bears the OBJ function. Thus, the rule in (115) contains the additional information that the f-structure for the NP daughter of V′ is the value of the OBJ attribute in the f-structure for the V′:

(115)
$$\begin{array}{llcc} \mathrm{V'} & \longrightarrow & \mathrm{V} & \mathrm{NP} \\ & & \phi(\hat{*}) = \phi(*) & (\phi(\hat{*})\ \textsc{obj}) = \phi(*) \end{array}$$

mother's f-structure's OBJ = self's f-structure

or, in the abbreviated notation:

(116)
$$\begin{array}{llcc} \mathrm{V'} & \longrightarrow & \mathrm{V} & \mathrm{NP} \\ & & \uparrow = \downarrow & (\uparrow \textsc{obj}) = \downarrow \end{array}$$

Some LFG work follows another abbreviatory convention according to which the annotation $\uparrow = \downarrow$ is omitted when it is the only annotation on a node. According to this convention, a rule like (116) can be written as:

(117)
$$\begin{array}{llcc} \mathrm{V'} & \longrightarrow & \mathrm{V} & \mathrm{NP} \\ & & & (\uparrow \textsc{obj}) = \downarrow \end{array}$$

In this book we will try to be as explicit as possible, so we will not follow this convention of omitting equations.

Restricting ourselves to rule annotations referring only to the f-structures corresponding to a daughter node and the mother node in a phrase structure rule makes a strong claim about the local applicability of syntactic constraints. For instance, we cannot refer to the grandmother node in a tree, or to its f-structure. This means that nonlocal syntactic relations are statable only in functional terms, not in terms of constituent structure configuration. Within the tree, only local phrase structure relations can be constrained by phrase structure rules.[13]

3.2. Lexical Entries

We can use the same notation in writing lexical entries that we used in annotations on phrase structure rules. For instance, assume that we would like to describe a c-structure/f-structure pair like the following:

(118)
$$\begin{array}{c} \mathrm{V} \\ | \\ \textit{yawned} \end{array} \longrightarrow \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{yawn}\langle\textsc{subj}\rangle\text{’} \\ \textsc{tense} & \textsc{pst} \end{bmatrix}$$

The following lexical entry for *yawned* provides information about the f-structure corresponding to V, the immediately dominating c-structure node:

(119)
$$\begin{array}{lll} \textit{yawned} & \mathrm{V} & (\uparrow \textsc{pred}) = \text{‘}\textsc{yawn}\langle\textsc{subj}\rangle\text{’} \\ & & (\uparrow \textsc{tense}) = \textsc{pst} \end{array}$$

This lexical entry asserts that the f-structure $\uparrow$ corresponding to the V node immediately dominating *yawned* has an attribute PRED whose value is the semantic form ‘YAWN⟨SUBJ⟩’, and an attribute TENSE whose value is PST. The f-structure

[13] Some analyses in LFG involve reference to the f-structures of sister nodes in the phrase structure rule: see Chapter 6, Section 4.

displayed in (118) is the minimal solution to these constraints, the smallest f-structure that satisfies the constraints.[14]

3.2.1. ↑ in Lexical Entries

The use of ↑ in a lexical entry is exactly the same as its use in a rule: ↑ refers to the c-structure node dominating the word itself. This can be seen more easily if we recast the lexical entry in (119) in the equivalent phrase structure rule format:

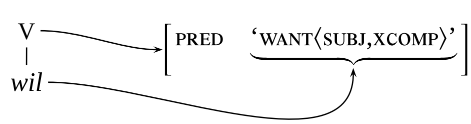
(120) V ⟶ *yawned*
(↑ PRED) = 'YAWN⟨SUBJ⟩'
(↑ TENSE) = PST

3.2.2. ↓ in Lexical Entries

In most cases, lexical entries specify only information about ↑, the f-structure of the immediately dominating c-structure node. Some analyses also refer to properties of the f-structure ↓ corresponding to the word itself and how the f-structure for the word relates to the f-structure for the immediately dominating node. For example, Zaenen and Kaplan (1995) explore an analysis of word order constraints in Dutch which assumes lexical entries such as the partial entry in (121) for the verb *wil* 'want':

(121) *wil* V (↑ PRED) = ↓
↓ = 'WANT⟨SUBJ, XCOMP⟩'

In this lexical entry, ↑ refers to the f-structure of the c-structure node V, and ↓ refers to the f-structure of the terminal node, the word *wil*. The structure associated with *wil* is the semantic form 'WANT⟨SUBJ, XCOMP⟩'. According to this lexical entry, then, the value of the PRED attribute of *wil* is the structure associated with the terminal node *wil*. The entire configuration is depicted in (122):

(122)


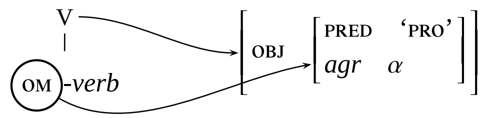
Bresnan et al. (2016) also use ↓ in lexical entries of words containing *incorporated pronouns* to anchor these pronouns to particular positions in the tree (for a discussion of incorporated pronouns, see Chapter 14, Section 1). For instance, Bresnan et al. (2016, page 160) propose that the object marker (abbreviated as OM) that appears with Chicheŵa transitive verbs has the following lexical entry, where *agr* is an abbreviatory symbol representing the attributes PERS, NUM and GEND:

[14]We rely here on a simplified view of the relation between elements of the string and nodes in the c-structure. See Chapter 3, Section 5 for a more complete view, and Chapter 11 for full details.

(123) OM- $(\uparrow \textsc{obj}) = \downarrow$
$(\downarrow agr) = \alpha$
$(\downarrow \textsc{pred}) = \text{`}\textsc{pro}\text{'}$

According to this analysis, a Chicheŵa transitive verb with an incorporated object pronoun prefix participates in the configuration in (124):

(124)



3.3. An Example

We now have the notational equipment to do a complete analysis of a sentence like *David yawned*. For clarity, in the following example the rules and lexical entries have been considerably simplified; for example, the phrase structure rules expanding VP and NP are clearly too impoverished to account for very many constructions in English.

We assume the following annotated phrase structure rules:

(125)
$$\begin{aligned}
\text{IP} &\longrightarrow \begin{pmatrix}\text{NP}\\ (\uparrow \textsc{subj}) = \downarrow\end{pmatrix} \begin{pmatrix}\text{I}'\\ \uparrow = \downarrow\end{pmatrix}\\
\text{I}' &\longrightarrow \begin{pmatrix}\text{I}\\ \uparrow = \downarrow\end{pmatrix} \begin{pmatrix}\text{VP}\\ \uparrow = \downarrow\end{pmatrix}\\
\text{VP} &\longrightarrow \begin{pmatrix}\text{V}\\ \uparrow = \downarrow\end{pmatrix}\\
\text{NP} &\longrightarrow \begin{pmatrix}\text{N}\\ \uparrow = \downarrow\end{pmatrix}
\end{aligned}$$

In English, the specifier of IP is associated with the grammatical function SUBJ. Other daughter nodes in the rules in (125) are heads or complements of functional categories, and are associated with the annotation $\uparrow = \downarrow$, requiring that they correspond to the same f-structure as the mother node. Parentheses around each annotated daughter node indicate that all of the daughter nodes are optional; see Chapter 3, Section 3.7 for a discussion of phrase structure optionality.

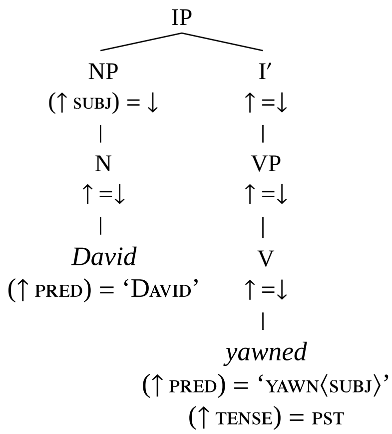
We also make use of the following simplified lexical entries:

(126) *yawned* V $(\uparrow \textsc{pred}) = \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'}$
$(\uparrow \textsc{tense}) = \textsc{pst}$

David N $(\uparrow \textsc{pred}) = \text{`David'}$

These rules and lexical entries admit the following tree, with as yet uninstantiated variables $\uparrow$ and $\downarrow$ over f-structures:

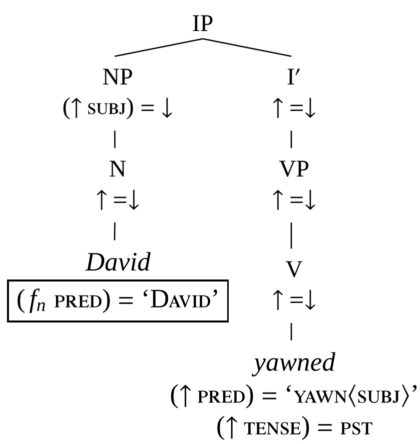
(127) *David yawned.*



The next task is to instantiate the ↑ and ↓ metavariables to the f-structures that they stand for in this example. It will be useful to have names for the f-structures corresponding to each node. Taking advantage of the coincidental fact that in this tree, every node has a different label, we will give the name f_v to the f-structure corresponding to the node labeled V, f_{vp} to the f-structure for the node labeled VP, and so on.

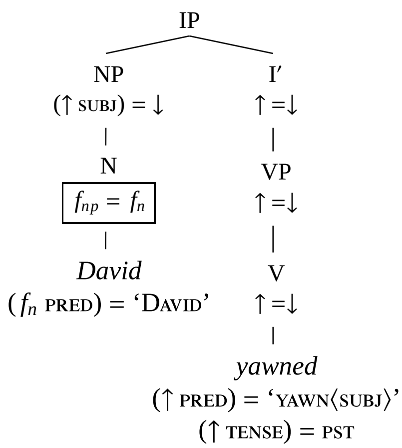
We begin with the information contributed by the lexical entry for *David*. The f-structure variable ↑ in the annotation (↑ PRED) = ‘DAVID’ for *David* refers to f_n, the f-structure of the N node immediately dominating the leaf node *David*, and so we replace ↑ in that expression with f_n.

(128)



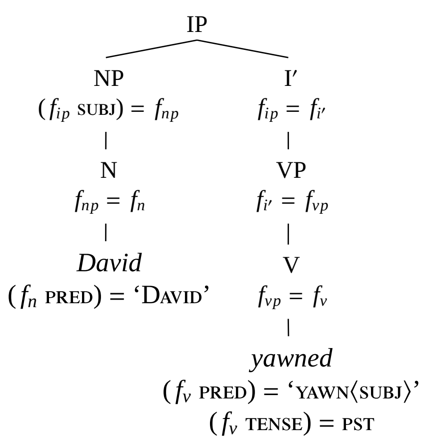
Let us now consider the N node. Its annotation is ↑ = ↓, meaning that the f-structure f_{np} corresponding to its mother node NP is the same as f_n, the f-structure for the N node:

(129)



In a similar way, we replace the ↑ and ↓ nodes in the rest of the tree with the names of the f-structures they refer to:

(130)



We now have an instantiated f-description of the f-structure for this sentence:

(131) $(f_{ip}$ SUBJ$) = f_{np}$
$f_{np} = f_n$
$(f_n$ PRED$)$ = ‘DAVID’
$f_{ip} = f_{i'}$
$f_{i'} = f_{vp}$
$f_{vp} = f_v$
$(f_v$ PRED$)$ = ‘YAWN⟨SUBJ⟩’
$(f_v$ TENSE$)$ = PST

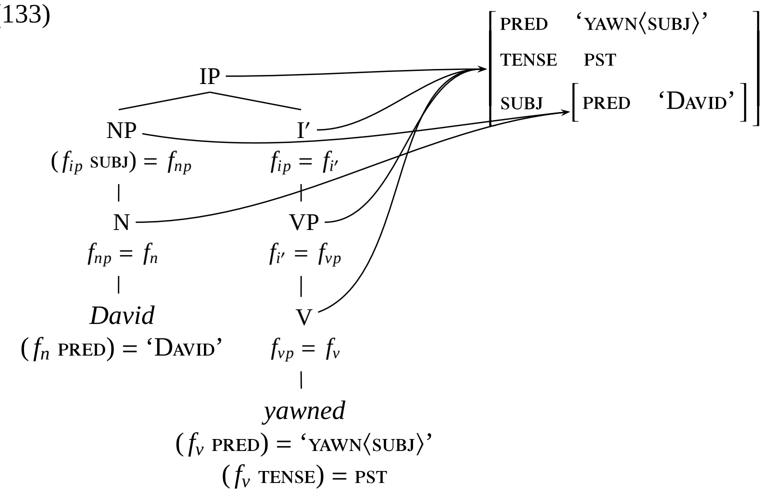
According to these constraints, f_{ip}, $f_{i'}$, f_{vp}, and f_v all name the same f-structure, which has three attributes, PRED, TENSE, and SUBJ. The SUBJ of this f-structure is f_{np}, which is also called f_n. The f-structure for this sentence is the minimal solution to these constraints, the f-structure that satisfies all of these constraints and contains no extra structure not mentioned in the constraints:

(132)

$$f_{ip}, f_{i'}, f_{vp}, f_v \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{yawn}\langle\textsc{subj}\rangle\text{’} \\ \textsc{tense} & \textsc{pst} \\ \textsc{subj} & f_{np}, f_n \begin{bmatrix} \textsc{pred} & \text{‘David’} \end{bmatrix} \end{bmatrix}$$

We have now deduced that the sentence *David yawned* has the following annotated c-structure and f-structure:

(133)



To summarize: an f-structure is admitted in correspondence with a particular constituent structure tree if the annotations on the phrase structure rules and the lexical items admit the pairing of that tree with that f-structure, and if the f-structure is the *minimal solution* — the smallest f-structure — that satisfies the constraints in the annotations and the lexical entries.

4. VARIATION IN GRAMMATICAL FUNCTION ENCODING

Grammatical functions are encoded in different ways in different languages, and languages may employ mixed or multiple strategies for grammatical function encoding. These typological differences are reflected in the constraints associated with lexical items and phrase structure rules.

As discussed in Chapter 2, Section 2.2, in some languages the grammatical function of a phrase is determined by its constituent structure position. Languages of this type make use of *configurational encoding* (Bresnan 1982a), and obey the *principle of endocentricity* (Bresnan et al. 2016): specifier and complement positions at constituent structure are associated with particular grammatical functions by means of annotations on phrase structure rules.

In other languages, there may be no uniform position in which a particular grammatical function must appear; instead, the grammatical role of a phrase is marked morphologically or by means of a preposition or particle. This is what Bresnan (1982a) calls *nonconfigurational encoding*, and Bresnan et al. (2016) call *lexocentric organization*: an association between morphological marking and syntactic function. Languages may tend to employ one of these types of encoding more heavily, but there are many cases in which a single language employs both types. For instance, in English, the object grammatical functions are encoded configurationally; in contrast, the oblique functions are encoded by means of prepositional marking. Below, we will examine other languages making use of a combination of these strategies.

In an important typological study, Nichols (1986) shows that some languages are *head marking* and some are *dependent marking*: in other words, the surface indication of grammatical function can appear either on the argument of a predicate (dependent marking) or on the predicate itself (head marking). Often, this surface indication involves nonconfigurational encoding, with morphological marking of grammatical function on either the head or the dependent. In fact, though, configurational languages can be said to exhibit a type of dependent marking, since a surface syntactic property of the dependent — its constituent structure position — indicates its grammatical function. We will see examples of both head-marking and dependent-marking languages below.

In the following, we illustrate the kind of variability that LFG predicts by examining simple structures in four typologically different languages: Balinese, Ancient Greek, Chicheŵa, and Bulgarian. In the final section, we provide a more detailed snapshot of the copular construction in several languages as an illustration of variability with respect to a single construction. These sketches are not intended as complete analyses of these languages or the constructions we discuss; only enough detail is provided so that broad outlines become evident. A more detailed grammar for English is provided in the Appendix. For very interesting discussions of nonconfigurationality, head marking, and dependent marking in a variety of languages, see Nordlinger (1998) and Bresnan et al. (2016). The analyses in this section make use of the following definition of the abbreviatory symbol GGF, which ranges over governable grammatical functions; see Chapter 6, Section 1.2 for more discussion of the use of abbreviatory symbols such as GGF:

(134) $\text{GGF} \equiv \{\text{SUBJ} \mid \text{OBJ} \mid \text{OBJ}_\theta \mid \text{COMP} \mid \text{XCOMP} \mid \text{OBL}_\theta\}$

4.1. Balinese

In Balinese, as described by Arka (2003), the grammatical functions SUBJ, OBJ, and OBJ_θ are primarily encoded configurationally. This means that phrase structure rules contain specifications of particular grammatical functions: just as in English (Chapter 4, Section 2), the specifier position of IP is filled by the subject, and the object appears as the first nominal complement of V.[15] These principles of mapping between c-structure and f-structure configurations are reflected in the annotations on the rules given in (135): heads of phrases bear the annotation $\uparrow = \downarrow$, ensuring that a phrase and its head correspond to the same f-structure; the specifier of the functional category IP bears the annotation $(\uparrow \textsc{subj}) = \downarrow$, ensuring that it is associated with the grammatical function SUBJ; the S complement of the functional category I is an f-structure co-head, bearing the annotation $\uparrow = \downarrow$; and the complement of the lexical category V bears the annotation $(\uparrow \textsc{obj}) = \downarrow$, ensuring that it is associated with the grammatical function OBJ.

(135)
$$
\begin{array}{lll}
\mathrm{IP} & \longrightarrow & \left(\begin{array}{c}\mathrm{NP}\\ (\uparrow \textsc{subj}) = \downarrow\end{array}\right) \left(\begin{array}{c}\mathrm{I}'\\ \uparrow = \downarrow\end{array}\right)\\
\mathrm{I}' & \longrightarrow & \left(\begin{array}{c}\mathrm{I}\\ \uparrow = \downarrow\end{array}\right) \left(\begin{array}{c}\mathrm{S}\\ \uparrow = \downarrow\end{array}\right)\\
\mathrm{S} & \longrightarrow & \left\{ \begin{array}{c}\mathrm{VP}\\ \uparrow = \downarrow\end{array} \mid \begin{array}{c}\mathrm{NP}\\ (\uparrow \textsc{ggf}) = \downarrow\end{array} \right\}^{*}\\
\mathrm{VP} & \longrightarrow & \left(\begin{array}{c}\mathrm{V}'\\ \uparrow = \downarrow\end{array}\right)\\
\mathrm{V}' & \longrightarrow & \left(\begin{array}{c}\mathrm{V}\\ \uparrow = \downarrow\end{array}\right) \left(\begin{array}{c}\mathrm{NP}\\ (\uparrow \textsc{obj}) = \downarrow\end{array}\right)
\end{array}
$$

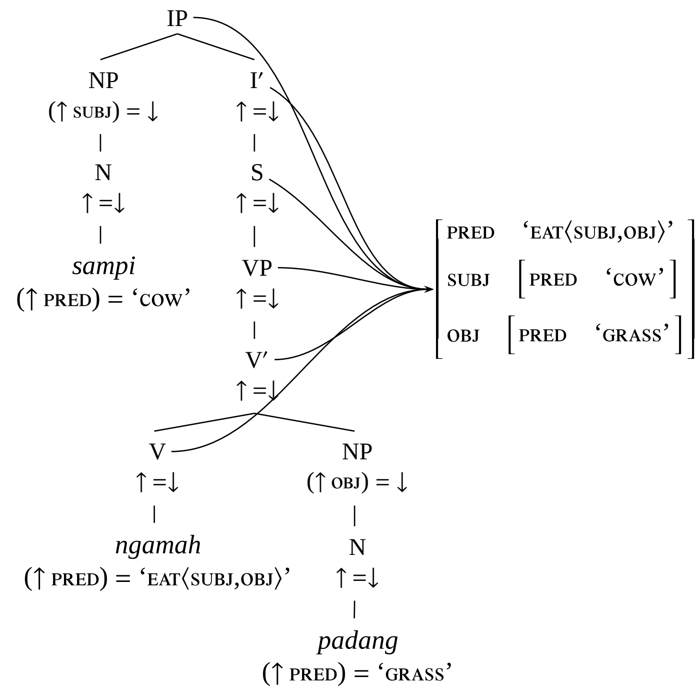
Predicates specify a list of the governable grammatical functions that they require:

(136) *ngamah* V $(\uparrow \textsc{pred}) =$ ‘EAT⟨SUBJ,OBJ⟩’

The c-structure and f-structure for the sentence *sampi ngamah padang* ‘a cow eats grass’ are given in (137), with the relation between the clausal head c-structure nodes and the main f-structure indicated by arrows:

[15] Balinese exhibits a symmetric, “Philippine-type” alternation in morphosyntactic alignment in transitive verbs, as described in Chapter 2, Section 5.5.3: in objective voice (OV) the theme or patient argument appears as the subject, while in agentive voice (AV) the more agentive argument appears as the subject.

(137) *sampi ngamah padang*
cow eat.AV grass
'A cow eats grass.'



The requirement for the presence of a SUBJ and an OBJ is lexically specified by the verb, and the grammatical function of each argument is determined by its phrase structure position.

4.2. Ancient Greek

Ancient Greek is typologically quite different from Balinese. Ancient Greek is a nonconfigurational language; unlike in Balinese, phrase structure configuration does not determine the grammatical function of an Ancient Greek phrase.[16] Instead, grammatical function is determined by morphological casemarking on the argument phrase.

[16]The analysis of Ancient Greek presented here relies on the work of Dik (1995, 2007) on the relation between word order and information structure in Ancient Greek, and on the work of Haug (2008a,b, 2011, 2012) on Ancient Greek syntax. The rules provided are, as with Balinese, necessarily simplified for the purposes of exposition.

$$
\text{(138)}\quad
\begin{array}{lll}
\text{CP} & \longrightarrow & \begin{pmatrix} \text{XP} \\ (\uparrow \textsc{dis}) = \downarrow \\ (\uparrow \textsc{ggf}) = \downarrow \end{pmatrix} \begin{pmatrix} \text{C}' \\ \uparrow = \downarrow \end{pmatrix} \\
\text{C}' & \longrightarrow & \begin{pmatrix} \text{C} \\ \uparrow = \downarrow \end{pmatrix} \begin{pmatrix} \text{S} \\ \uparrow = \downarrow \end{pmatrix} \\
\text{S} & \longrightarrow & \begin{pmatrix} \text{XP} \\ (\uparrow \textsc{ggf}) = \downarrow \end{pmatrix} \begin{pmatrix} \text{XP} \\ (\uparrow \textsc{ggf}) = \downarrow \end{pmatrix} \begin{pmatrix} \text{V} \\ (\uparrow = \downarrow) \end{pmatrix} \begin{matrix} \text{XP}^{*} \\ (\uparrow \textsc{ggf}) = \downarrow \end{matrix}
\end{array}
$$

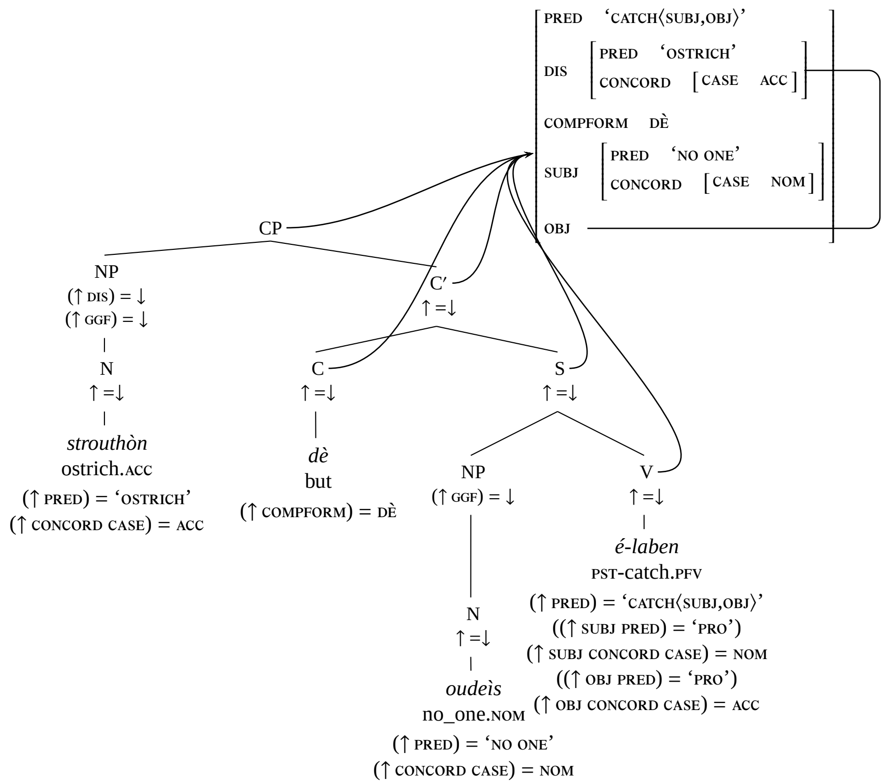
In Ancient Greek, the specifier position of CP is associated with a phrase that fills the DIS function at f-structure. This is indicated by the annotation $(\uparrow \textsc{dis}) = \downarrow$; unbounded dependencies are discussed further in Chapter 17. The DIS function is an overlay function and must be syntactically or semantically linked to a primary non-overlay function: in this CP rule, the annotation $(\uparrow \textsc{ggf}){=}\downarrow$ requires this phrase to bear not only the DIS role, but also a grammatical function GGF in the sentence.[17] The XP daughters of S are also annotated with the equation $(\uparrow \textsc{ggf}){=}\downarrow$, indicating that a phrase with any grammatical function can appear there. Complementizers and some conjunctions can be analyzed as appearing in C.

In contrast to Balinese, the Ancient Greek verb specifies a great deal of information about its arguments. The case of each argument is specified, and additionally an optional PRED value for each argument is provided. As described in Section 2.4 of this chapter, this allows for the absence of overt phrasal arguments (pro-drop): an Ancient Greek sentence may consist simply of a verb, with no overt subject or object phrases present at c-structure. In such a case, the PRED values of the arguments of the verb come from the verb's specifications.

$$
\text{(139)}\quad \textit{élaben}\quad \text{V}\quad
\begin{array}{l}
(\uparrow \textsc{pred}) = \text{‘}\textsc{catch}\langle \textsc{subj},\textsc{obj}\rangle\text{’} \\
((\uparrow \textsc{subj pred}) = \text{‘}\textsc{pro}\text{’}) \\
(\uparrow \textsc{subj concord case}) = \textsc{nom} \\
((\uparrow \textsc{obj pred}) = \text{‘}\textsc{pro}\text{’}) \\
(\uparrow \textsc{obj concord case}) = \textsc{acc}
\end{array}
$$

[17] This is a simplification, since phrases from embedded clauses can appear in the specifier of CP. The annotation $(\uparrow \textsc{ggf}) = \downarrow$ on the specifier of CP can be read as an abbreviated equivalent (in a monoclausal sentence) for a more complex annotation involving specification of a path through the f-structure, as we will see in Chapter 17.

(140) *strouthòn dè oudeìs é-laben*
ostrich.ACC but no_one.NOM PST-catch.PFV
‘But no one has caught an ostrich.’



The verb requires its subject to be in the nominative case; phrase structural annotations allow the phrase *oudeìs* ‘no one’ to bear any governable grammatical function GGF, but only the SUBJ grammatical function is compatible with the nominative casemarking requirements imposed by the verb and captured by the equation (↑ CONCORD CASE)=NOM for *oudeìs*. Similarly, its accusative casemarking requires the phrase *strouthòn* ‘ostrich’ to bear the OBJ function.

The verb also provides optional ‘PRO’ values, enclosed in parentheses, for the PRED of its subject and object. These values do not appear in the final f-structure, since the overt subject and object noun phrases *oudeìs* ‘no one’ and *strouthòn* ‘ostrich’ are present and contribute their PRED values to the final f-structure. If these phrases did not appear, the ‘PRO’ value optionally provided by the verb would appear as the value of the PRED of these arguments.

4.3. Chicheŵa

Chicheŵa is typologically different from both Balinese and Ancient Greek, and illustrates an interesting combination of configurational and nonconfigurational characteristics (Bresnan and Mchombo 1987; Bresnan et al. 2016). The relevant phrase structure rules for Chicheŵa are:

(141)
$$\mathrm{S} \longrightarrow \left(\begin{array}{c}\mathrm{NP}\\ (\uparrow \textsc{subj}) = \downarrow\end{array}\right), \left(\begin{array}{c}\mathrm{NP}\\ \downarrow\in (\uparrow \textsc{dis})\end{array}\right), \left(\begin{array}{c}\mathrm{VP}\\ \uparrow=\downarrow\end{array}\right)$$
$$\mathrm{VP} \longrightarrow \left(\begin{array}{c}\mathrm{V'}\\ \uparrow=\downarrow\end{array}\right)$$
$$\mathrm{V'} \longrightarrow \left(\begin{array}{c}\mathrm{V}\\ \uparrow=\downarrow\end{array}\right) \left(\begin{array}{c}\mathrm{NP}\\ (\uparrow \textsc{obj}) = \downarrow\end{array}\right)$$

These rules show that grammatical functions in Chicheŵa are specified configurationally to some extent, though not in the same way as in Balinese. Like Balinese (and Ancient Greek), Chicheŵa makes use of the exocentric category S; it differs from Balinese, however, in that the daughters of S are the subject, a DIS phrase (which is the topic at the separate level of information structure; see Chapter 10), and the VP, which may appear in any order (the first rule in (141) is an unordered ID rule, as described in Section 1.5 of this chapter). There is a configurationally specified postverbal object position: the complement of the lexical category V is OBJ, as indicated by the equation (↑ OBJ) = ↓.

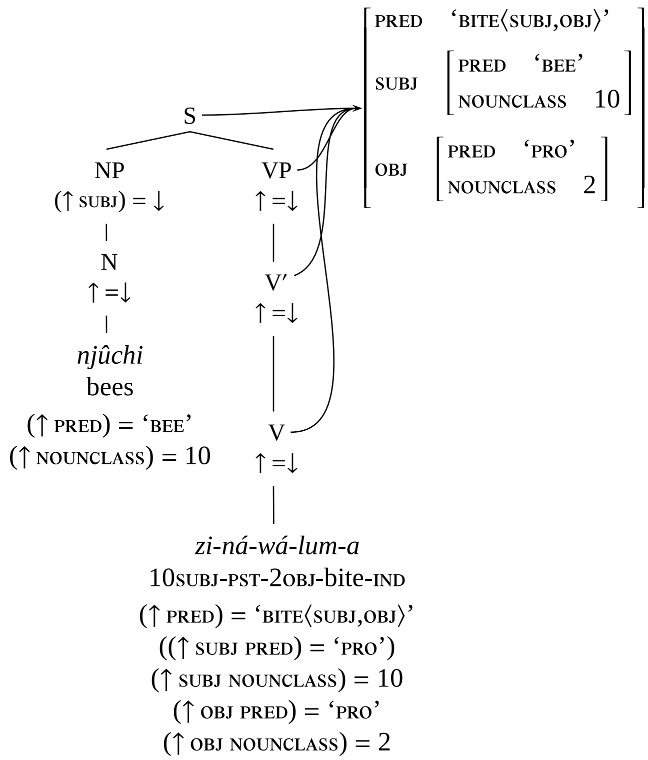
The lexical entry for the Chicheŵa transitive verb *zi-ná-wá-lum-a* 'bit' is given in (142):

(142) *zi-ná-wá-lum-a* V (↑ PRED) = 'BITE⟨SUBJ,OBJ⟩'
((↑ SUBJ PRED) = 'PRO')
(↑ SUBJ NOUNCLASS) = 10
(↑ OBJ PRED) = 'PRO'
(↑ OBJ NOUNCLASS) = 2

Unlike the Balinese verb, and like the Ancient Greek verb, this verb contains an optional 'PRO' value for the PRED of its subject; this means that an overt SUBJ phrase may but need not appear. The verb also carries information about the noun class of its arguments: Chicheŵa, like many Bantu languages, has a complex noun class system, and the prefix *zi-* indicates that the SUBJ belongs to noun class 10.

The OBJ is treated differently from the SUBJ. As Bresnan and Mchombo (1987) show, this verb contains an incorporated pronominal object *wá*. This means that the equation specifying the OBJ PRED is obligatory, not optional. The c-structure and f-structure for the sentence *njûchi zi-ná-wá-lum-a* 'The bees bit them' are displayed in (143):

(143) *njûchi zi-ná-wá-lum-a*
bees 10SUBJ-PST-2OBJ-bite-IND
'The bees bit them.'

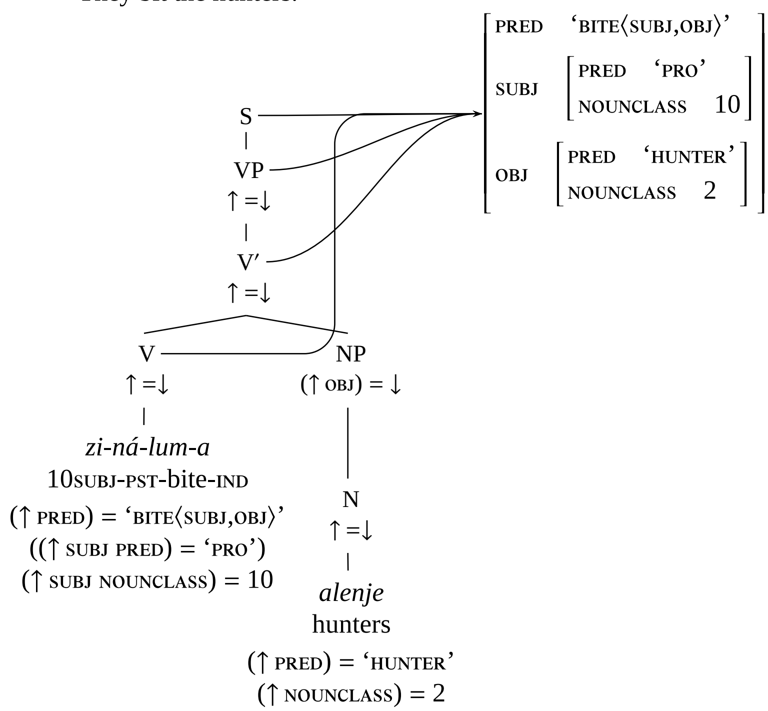


When the incorporated object pronoun *wá* does not appear, the sentence is incomplete unless an overt noun phrase is present. The lexical entry for the verb *zi-ná-lum-a* 'bit', with no incorporated OBJ pronoun, is:

(144) *zi-ná-lum-a* V (↑ PRED) = 'BITE⟨SUBJ,OBJ⟩'
((↑ SUBJ PRED) = 'PRO')
(↑ SUBJ NOUNCLASS) = 10

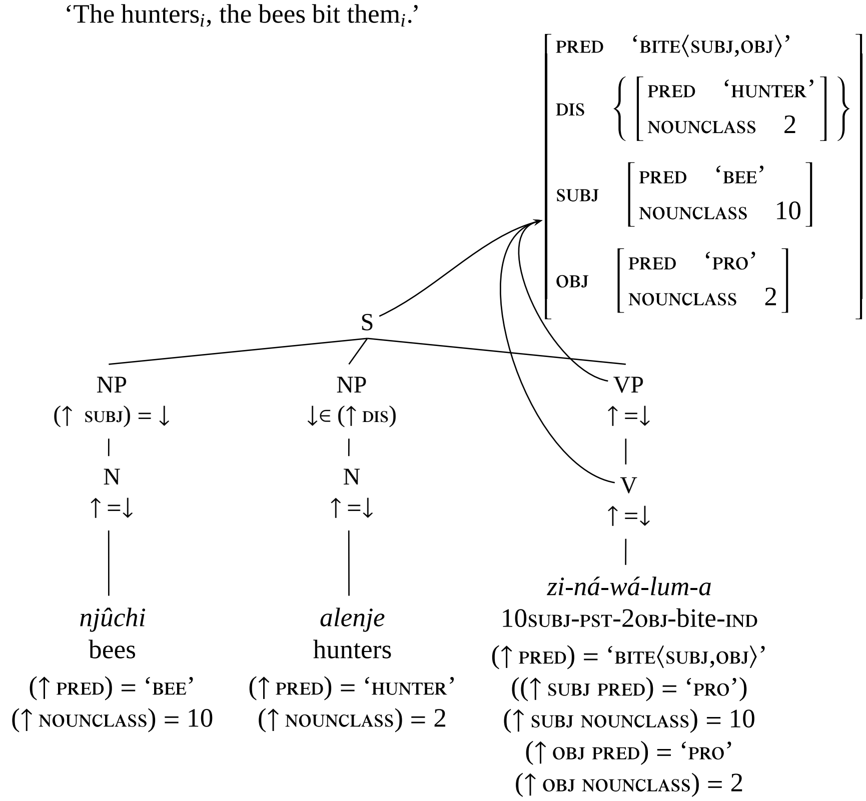
In the following Chicheŵa sentence, there is no overt SUBJ noun phrase. This means that the subject noun phrase is an incorporated pronoun, as optionally specified by the verb. An overt OBJ noun phrase, *alenje* 'hunters', also appears; if there were no overt OBJ noun phrase, the sentence would be incomplete and therefore ungrammatical. The grammatical function of *alenje* is determined by the phrase structure configuration in which it appears:

(145) *zi-ná-lum-a* *alenje*
10SUBJ-PST-bite-IND hunters
'They bit the hunters.'



It is also possible for the incorporated object pronoun to be anaphorically linked to an overt, displaced DIS noun phrase that has the function of topic at the separate level of information structure, a relationship that we do not indicate in the functional structure. In this case, the incorporated OBJ pronoun *wá* appears, as shown in (146) (Bresnan and Mchombo 1987, page 745). Example (146) is different from (145) in that the phrase *alenje* 'hunters' appears not in canonical OBJ position, but in the c-structure position associated with a DIS phrase (Bresnan and Mchombo 1987). As DIS is an overlay function, this phrase must therefore also be linked to a primary (nonoverlay) function. In this case, the DIS phrase is anaphorically linked to the incorporated OBJ pronoun, as indicated by the subscript *i* indexes in the translation.

(146) *njûchi alenje zi-ná-wá-lum-a*
bees hunters 10SUBJ-PST-2OBJ-bite-IND
'The hunters$_i$, the bees bit them$_i$.'



As these examples illustrate, the pronominal typology predicted by LFG is richer than the one proposed by Jelinek (1984), who hypothesizes that all non-configurational languages should be analyzed as pronominal-incorporating, as we have analyzed the Chicheŵa incorporated object pronoun. Dahlstrom (1986a) shows that this simple proposal does not provide an adequate account of the facts in Meskwaki; Bresnan and Mchombo (1987), Austin and Bresnan (1996), Nordlinger (1998), and Toivonen (2000) also show that an adequate analysis of the phrasal and functional structure of many languages must allow the possibility for a PRED value to be optionally contributed. In other words, incorporated pronouns contributing a PRED (like the Chicheŵa incorporated object pronoun *wá*) must be distinguished from agreement markers which do not contribute a PRED as well as from forms which, like the Chicheŵa subject marker, are ambiguous between the two, optionally contributing a PRED.

4.4. Bulgarian

Bulgarian is unusual in combining relatively free word order with a lack of nominal inflection (Rudin 1985): only pronominal forms show casemarking. In some cases, the subject can be identified as the argument that agrees with the verb; additionally, Bulgarian allows clitic doubling, so that the case, gender, and number of clitic-doubled arguments are specified. In other cases, however, these clues do not serve to disambiguate the grammatical functions of the argument phrases, and a phrase may be associated with any of the grammatical functions selected by the predicate. In such cases, only contextual information and world knowledge help in determining the intended structure.

The relevant phrase structure rules for Bulgarian are:

(147)
$$\mathrm{IP} \longrightarrow \left(\begin{array}{c}\mathrm{NP}\\ \downarrow\in(\uparrow \textsc{dis})\\ (\uparrow \textsc{ggf}) = \downarrow\end{array}\right) \left(\begin{array}{c}\mathrm{I'}\\ \uparrow=\downarrow\end{array}\right)$$

$$\mathrm{I'} \longrightarrow \left(\begin{array}{c}\mathrm{I}\\ \uparrow=\downarrow\end{array}\right) \left(\begin{array}{c}\mathrm{S}\\ \uparrow=\downarrow\end{array}\right)$$

$$\mathrm{I} \longrightarrow \left(\begin{array}{c}\widehat{\mathrm{N}}\\ (\uparrow \textsc{obj}) = \downarrow\end{array}\right) \left(\begin{array}{c}\mathrm{I}\\ \uparrow=\downarrow\end{array}\right)$$

$$\mathrm{S} \longrightarrow \left\{ \begin{array}{c}\mathrm{NP}\\ (\uparrow \textsc{ggf}) = \downarrow\end{array} \;\middle|\; \begin{array}{c}\mathrm{V}\\ \uparrow=\downarrow\end{array} \right\}^{*}$$

At this rough level of detail, these rules are very similar to the rules for languages such as Ancient Greek, which also allow relatively free word order. An important difference is that the I rule allows adjunction of a non-projecting $\widehat{\mathrm{N}}$ object clitic to I.

The third person singular past tense verb *vidja* 'saw' has this lexical entry:

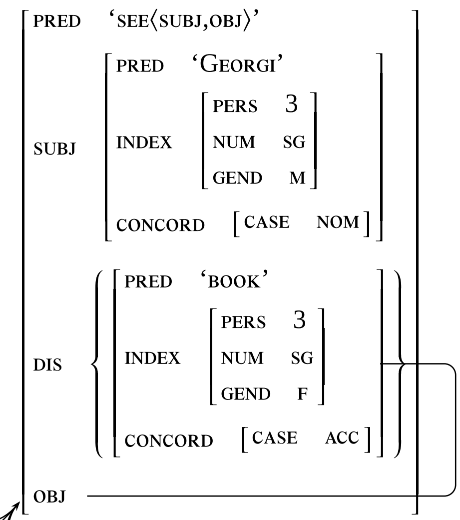
(148) *vidja* V
$$\begin{array}{l}(\uparrow \textsc{pred}) = \text{‘}\textsc{see}\langle\textsc{subj},\textsc{obj}\rangle\text{’}\\ ((\uparrow \textsc{subj pred}) = \text{‘}\textsc{pro}\text{’})\\ (\uparrow \textsc{subj index pers}) = 3\\ (\uparrow \textsc{subj index num}) = \textsc{sg}\\ (\uparrow \textsc{subj concord case}) = \textsc{nom}\\ (\uparrow \textsc{obj concord case}) = \textsc{acc}\end{array}$$

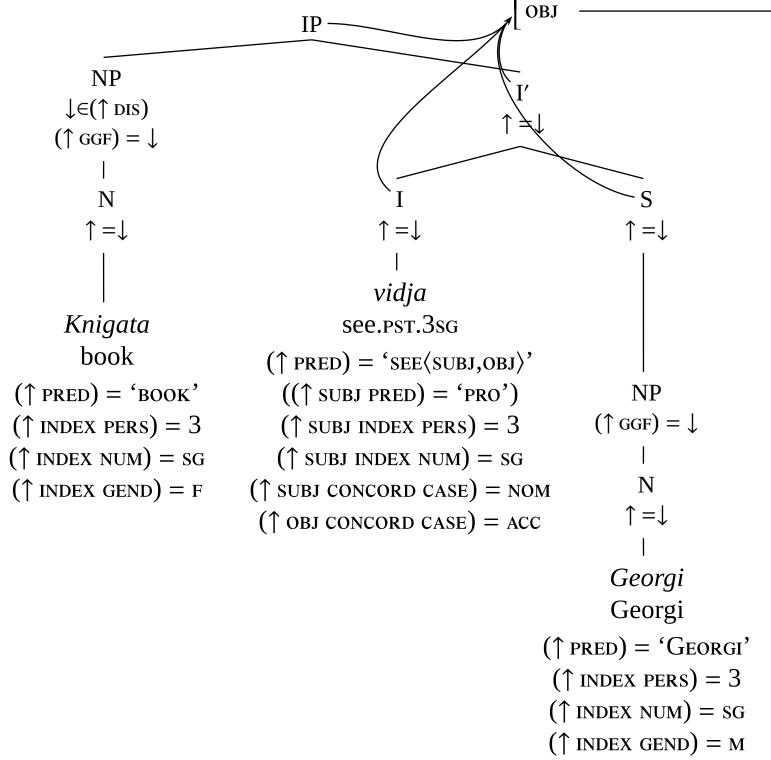
As Rudin (1985) shows, a Bulgarian clause can appear without an overt subject, as in Ancient Greek and Chicheŵa: the verb contains an optional equation specifying a pronominal value for the PRED of its subject. If the Bulgarian verb is transitive, either an overt object phrase or the object clitic pronoun must appear, since the verb does not specify a PRED value for its object.

Consider (149). The noun *knigata* 'the book' and the proper noun *Georgi* (a male name) are unmarked for case; each of them is compatible with either nominative or accusative case. The symbol GGF, which represents any governable grammatical function, is arbitrarily instantiated to SUBJ for *Georgi* and OBJ for *knigata* 'the book'. As Rudin (1985) notes, it is only world knowledge that enforces the interpretation of *knigata* 'the book' as the object of the verb *vidja* 'saw', and *Georgi* as its subject. Neither phrase structure position, casemarking, nor agreement requirements serve to disambiguate the syntactic role of these arguments.[18] However, in (149), the subject and object are distinguished in terms of information structure role: as discussed in Chapter 4, Section 2.3.1, the specifier of IP is a DIS position in Bulgarian, and the phrase appearing in the specifier of IP is interpreted as bearing a prominent information structure role. Here, the object *knigata* 'the book' is likely to be interpreted as in focus.

[18]But see King (1995) and Mahowald (2011) for discussion of ways in which word order constraints may contribute to disambiguation in similar constructions.

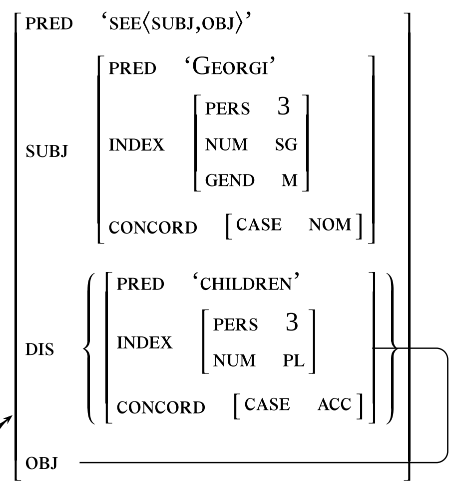
(149) *Knigata vidja Georgi.*
book see.PST.3SG Georgi
'It is the book that Georgi saw.'

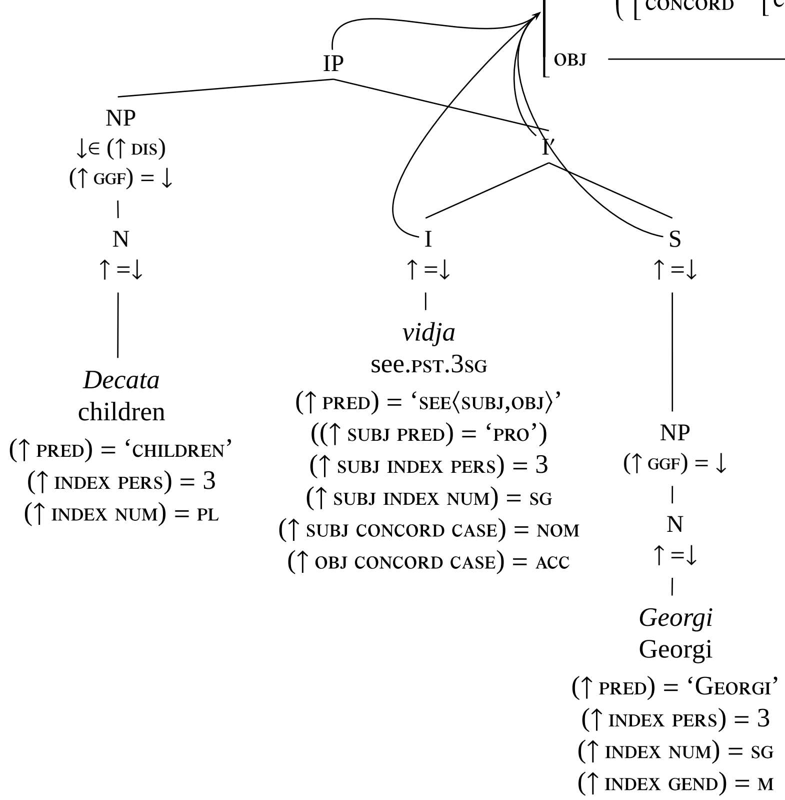




Example (150) differs from (149) in that the DIS noun phrase *decata* 'the children' is plural. Thus, since the verb shows third person singular agreement with its SUBJ, the only available syntactic analysis is the one in which the third person singular phrase *Georgi* is the subject. In this example, *decata* 'the children' appears in the specifier of IP and can be interpreted as bearing the prominent information structure role of focus.

(150) *Decata* *vidja* *Georgi.*
children see.PST.3SG Georgi
'It is the children that Georgi saw.'

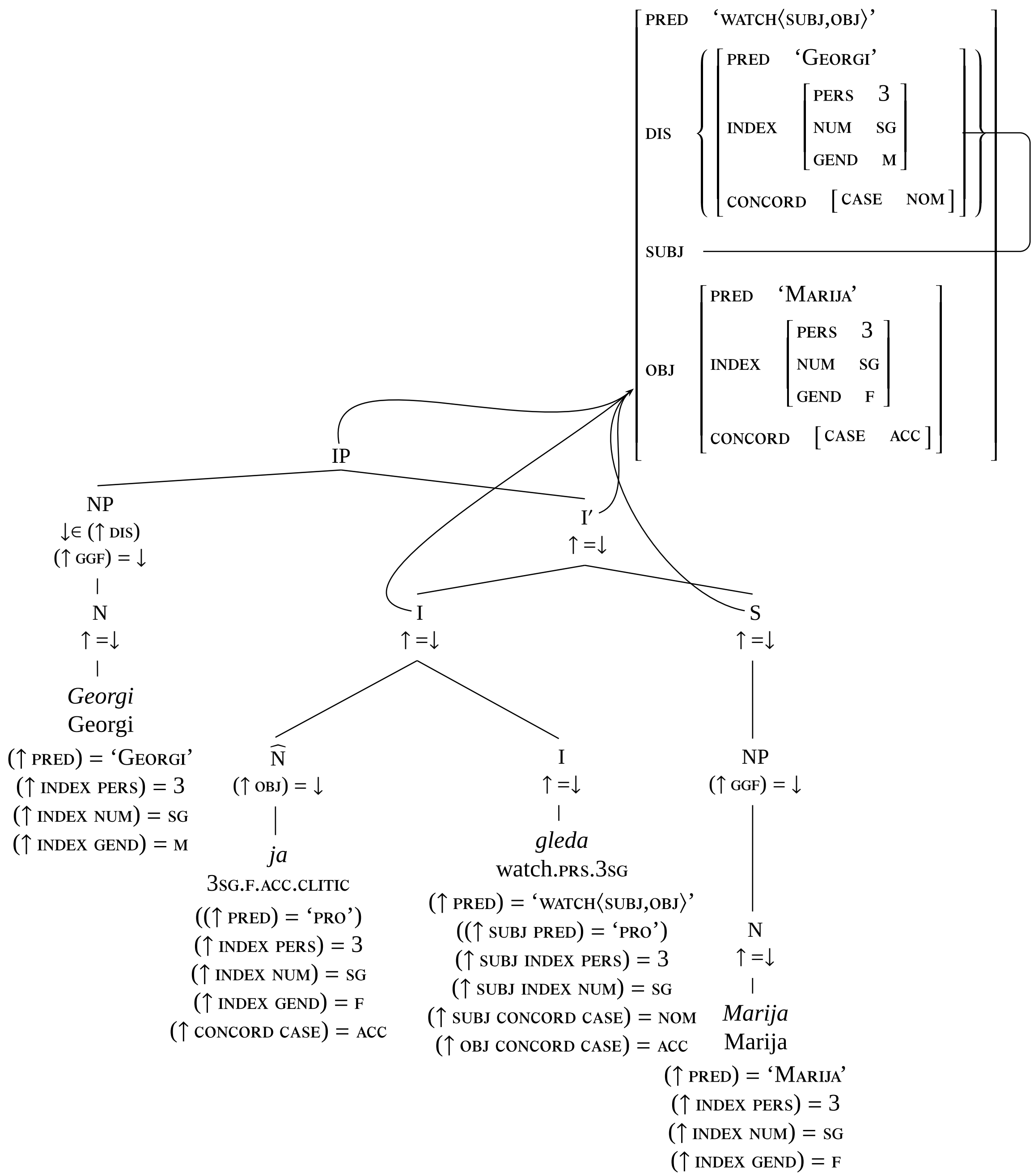




The presence of a doubled clitic object pronoun can also help to disambiguate a potentially ambiguous sentence; example (151) (page 202) is unambiguous.

Here, the subject *Georgi* appears in the specifier of IP, and is likely to be interpreted as a topic.

(151) *Georgi ja gleda Marija.*
Georgi 3SG.F.ACC.CLITIC watch.PRS.3SG Marija
'Georgi is watching Marija.'



The lexical entry for the feminine singular accusative clitic pronoun *ja* is:

(152) *ja* ((↑ PRED) = 'PRO')
(↑ INDEX PERS) = 3
(↑ INDEX NUM) = SG
(↑ INDEX GEND) = F
(↑ CONCORD CASE) = ACC

If there is no full object noun phrase, the PRED value for the OBJ function is given by the object clitic pronoun phrase. Since the PRED of the clitic pronoun is optional (as in Spanish; see Section 2.4 of this chapter) the presence of *ja* is also compatible with the OBJ being filled by the feminine phrase *Marija* (but not the masculine phrase *Georgi*, since that would produce a clash in GEND values).

The Balinese, Ancient Greek, Chicheŵa and Bulgarian examples presented in this section attest both to the diversity of expression found crosslinguistically and to the basic underlying unity of structure at a more abstract syntactic level.

4.5. Copular Constructions

Copular constructions represent an interesting case study with respect to many of the issues concerning syntactic correspondences that have been discussed in this and the previous chapter. Crosslinguistically, such constructions may vary in significant ways, despite having very similar meanings. In a language like English, for example, a copular verb must be used:

(153) a. *Fiona <u>is</u> a nurse.*

b. *The book <u>is</u> red.*

c. *The vase <u>is</u> on the table.*

Contrast this with comparable examples from Maori (154a), Japanese (154b) and Russian (154c), in which no verb appears in the sentence. The following examples are from Rosén (1996) citing Biggs (1969, page 24), Dalrymple et al. (2004a, page 190), and Attia (2008) citing Avgustinova and Uszkoreit (2003), respectively.

(154) a. *He taariana, te hoiho.*
INDF stallion DEF.SG horse
'The horse is a stallion.'

b. *hon wa akai*
book TOPIC red
'The book is red.'

c. *Boris na sobranii.*
Boris at meeting.LOC
'Boris is at a meeting.'

In some languages, both types of constructions — with and without a verb — exist, as these Hebrew examples from Falk (2004) show:

(155) a. *Pnina tinoket / b-a-bayit / nora xamuda.*
Pnina baby.F in-the-house awfully cute.F
'Pnina is a baby/in the house/awfully cute.'

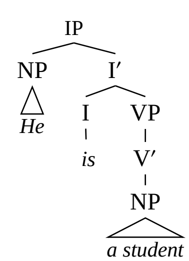
b. *Pnina hayta tinoket / b-a-bayit / nora xamuda.*
Pnina be.PST.3F.SG baby.F in-the-house awfully cute.F
'Pnina was a baby/in the house/awfully cute.'

Which of these two types of copular construction is used to encode the relevant relationship may vary according to a number of different factors including tense (as in the Hebrew examples), aspect, polarity, syntactic category, main versus subordinate clause status, and the precise nature of the semantic relation between the elements in the sentence. Crosslinguistically, whether or not a verbless construction is available does not invariably correlate with any particular one of these factors. In other languages, the copula may be expressed by use of a particle which does not exhibit all of the usual properties of a verb, or by inflectional marking on a non-verbal element in the sentence similar to that more usually associated with a verb: for details, see Curnow (1999) and Pustet (2003). Nordlinger and Sadler (2003, 2007) propose that the clausal PRED information which in other cases would be contributed by a verb is lexically associated with these other expressions.

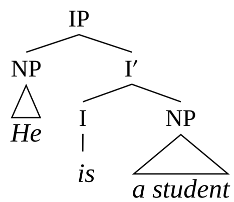
In terms of c-structure (and, by extension, the correspondence between c-structure and f-structure), there is a fundamental difference between copular constructions with a copular particle or verb and those without. Compare the c-structures for the copular constructions in English (156) and in Russian (157). In English, the copular verb appears in I: it precedes negation (*He is not a student*), and it inverts in question formation (*Is he a student?*).[19] There is no copular verb in (157); IP is headless.

[19] An alternative to the English c-structure in (156) is the c-structure in (a), which includes a VP node. The choice between the trees in (156) and (a) depends on whether a single-tier analysis is assumed (as shown in 161), for which the tree in (156) may be preferred in order to maintain the generalization that the complement of I is always an f-structure co-head, or a double-tier analysis (as shown in 162), for which the tree in (a) is appropriate.

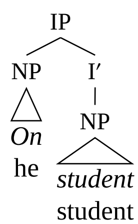
(a)



(156) *He is a student.*



(157) *On student.*
he student
'He is a student.'

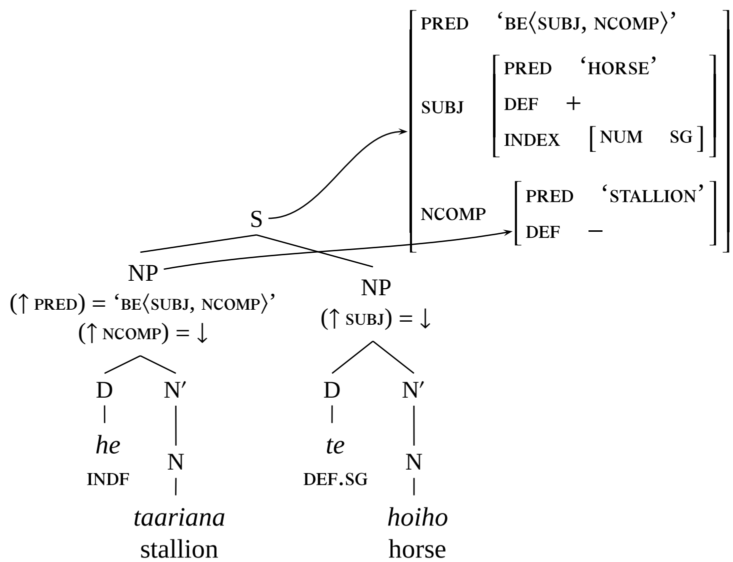


While we have seen that it is possible to have f-structures that are not related to any c-structure node, as in cases of pro-drop (example 3, Chapter 4, Section 1, page 126), the examples that have been presented in this chapter and earlier chapters have all included a verb which contributes the main PRED of the clause. In a copular construction including a verb such as (156), the verb is often assumed to introduce the main clausal PRED. In the case of verbless constructions such as (157), though, it is not immediately clear what contributes the main PRED that is required for the f-structure to be coherent. In turn, this raises questions relating to the analysis of copular constructions that do include a verb, and the broader issue of whether a unified analysis of copular constructions is possible and desirable. We will see that different analyses appear in the literature: for instance, it has been proposed that the copular verb in a sentence such as (156) contributes only tense and aspect information, with the main PRED contributed by the copular complement. Similarly, in the case of verbless constructions such as (157), different analyses are possible as to what contributes the main PRED at f-structure. A related issue, which has also been the subject of debate in the literature, concerns which grammatical functions the main PRED subcategorizes for. Before considering the grammatical functions that may be involved, we review two influential analyses of verbless copular constructions. The first proposes that the main clausal PRED is contributed by the phrase structure configuration (Section 4.5.1); the second proposes that the main clausal PRED is contributed by the complement (Section 4.5.2).

4.5.1. Main pred Contributed By Phrase Structure

Rosén (1996) proposes that in the case of a verbless copular construction like the Maori example in (154a), the phrase structure configuration rather than the lexical specifications of the words in the construction must introduce the copular relation. Under a constructional analysis such as this one, the PRED value that licenses the grammatical functions of non-verbal elements is introduced by the phrase structure of the copular construction.[20]

(158) *He taariana te hoiho.*
INDF stallion DEF.SG horse
'The horse is a stallion.'



As shown in (158), Rosén (1996) associates the clausal PRED with the first NP node in the c-structure of Maori, which is interpreted as the predicative complement.[21] This is one possible analysis of this construction.

4.5.2. Main pred Contributed By The Complement

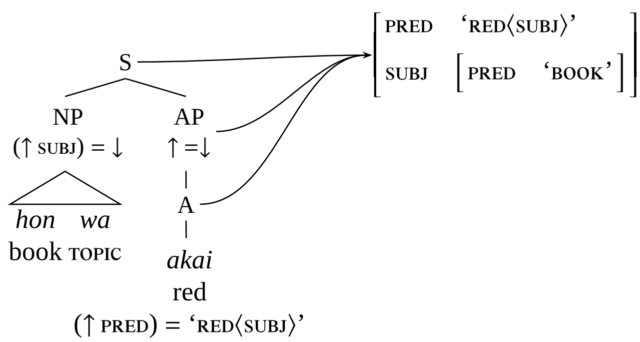
When a verb is not present, it can also be argued that it is the predicative complement that contributes the main clausal PRED, selecting for arguments just

[20]Other analyses of verbless copular constructions have been formulated in terms of an empty node rule (Chapter 6, Section 10.4). On Russian, see Dalrymple et al. (2004a); on Arabic, see Attia (2008).

[21]Rosén's analysis makes use of the grammatical role NCOMP, or nominal complement. This role is no longer in general use in LFG analyses, since it violates modularity by encoding c-structure distinctions (the phrase structure category of the complement) in the statement of f-structural subcategorization requirements. The current equivalent would be PREDLINK, discussed in Chapter 2, Section 1.8 and below, though the PREDLINK role is not associated with any particular phrase structure category.

as a verb would and resulting in a fundamentally different f-structure from that shown in (158). For example, according to Dalrymple et al.'s (2004a) analysis of Japanese sentences such as (154b), the lexical entry for *akai* 'red' includes (↑ PRED) = 'RED⟨SUBJ⟩'.

(159) *hon wa akai*
book TOPIC red
'The book is red.'



The two different approaches to the relationship between c-structure and f-structure shown in (158) and (159) are not restricted to the analysis of verbless copular constructions, but represent a major division in the possible analyses of copular constructions more generally. The two approaches are referred to as the "single-tier" analysis and the "double-tier" analysis. To illustrate the difference between the two, Nordlinger and Sadler (2007, pages 141–142) present two possible f-structure analyses of this verbless Russian copular construction:

(160) *Ona vrač.*
she doctor
'She is a doctor.'

Under a single-tier analysis, a non-verbal element in the copular construction is the syntactic head of the clause, as in the Japanese example in (159). The f-structure of a non-verbal element is therefore identified with the f-structure of the clause and contributes the necessary clausal PRED value. For (160), there must be a lexical entry for the predicative complement *vrač* 'doctor' which contributes the main clausal predicate and selects a subject, as shown in (161). This lexical entry may exist alongside a lexical entry for the same form which does not require a subject, as in a sentence like *A doctor came into the room*, where *a doctor* is not used predicatively.

(161) Single-tier analysis of *Ona vrač* 'She is a doctor':

$$\begin{bmatrix} \text{PRED} & \text{‘DOCTOR}\langle\text{SUBJ}\rangle\text{’} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{‘PRO’} \\ \text{INDEX} & \begin{bmatrix} \text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{GEND} & \text{F} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Under a double-tier approach, the relevant non-verbal elements are arguments, one of which is the subject. The main PRED that selects for these arguments can be supplied by a copular verb (or by a non-verbal particle or inflection which serves to establish the same kind of relationship; see, for example, Nordlinger and Sadler 2003 on Tariana), or it can be introduced by the phrase structure, as proposed by Rosén (1996) and illustrated in (158).

Two alternative double-tier analyses of (160) are shown in (162).[22] These differ with respect to the grammatical function that the non-verbal complement in a copular construction bears: that is, whether it is an open grammatical function whose SUBJ must be specified externally (XCOMP, as in example 162a), or a closed grammatical function (PREDLINK, as in example 162b).

(162) Alternative double-tier analyses of *Ona vrač* 'She is a doctor':

[22] A third kind of double-tier analysis with an oblique copular complement is proposed by Falk (2004) for locative complement constructions in English and Hebrew, and by Laczkó (2012) for locative and existential complement constructions in Hungarian (see also Bresnan et al. 2016, Chapter 12):

(a)
$$\begin{bmatrix} \text{PRED} & \text{‘BE}\langle\text{SUBJ,OBL}_\theta\rangle\text{’} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{‘PRO’} \\ \text{INDEX} & \begin{bmatrix} \text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{GEND} & \text{F} \end{bmatrix} \end{bmatrix} \\ \text{OBL} & \begin{bmatrix} \text{PRED} & \text{‘...’} \end{bmatrix} \end{bmatrix}$$

For other copular constructions in Hebrew, Falk argues for a PREDLINK analysis; Laczkó (2012) argues that a single-tier analysis is appropriate for Hungarian copular constructions involving attribution or classification, while for constructions involving identity or possession, a double-tier PREDLINK analysis is motivated.

a.
$$\begin{bmatrix} \text{PRED} & \text{`BE}\langle\text{SUBJ,XCOMP}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`PRO'} \\ \text{INDEX} & \begin{bmatrix} \text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{GEND} & \text{F} \end{bmatrix} \end{bmatrix} \\ \text{XCOMP} & \begin{bmatrix} \text{PRED} & \text{`DOCTOR}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \end{bmatrix} \end{bmatrix}$$

b.
$$\begin{bmatrix} \text{PRED} & \text{`BE}\langle\text{SUBJ,PREDLINK}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`PRO'} \\ \text{INDEX} & \begin{bmatrix} \text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{GEND} & \text{F} \end{bmatrix} \end{bmatrix} \\ \text{PREDLINK} & \begin{bmatrix} \text{PRED} & \text{`DOCTOR'} \end{bmatrix} \end{bmatrix}$$

Nordlinger and Sadler (2007, page 142) point out that although most treatments of copular constructions that include a verb assume a double-tier analysis (with the copular verb contributing the main clausal PRED), a single-tier analysis is also possible. Under such an approach, the verb contributes information about tense, aspect, mood, and other verbal features, while the non-verbal element contributes the main clausal PRED, meaning that the copular verb and the non-verbal predicate are functional co-heads of the clause.

In summary, two main approaches to the analysis of copular constructions have been put forward: the single-tier analysis, in which a non-verbal element supplies the main clausal PRED, and the double-tier analysis, in which the main clausal PRED is contributed by some other means (for example, by a copular verb or by the phrase structure). Double-tier analyses can be subdivided according to whether the complement's grammatical function is taken to be open or closed.

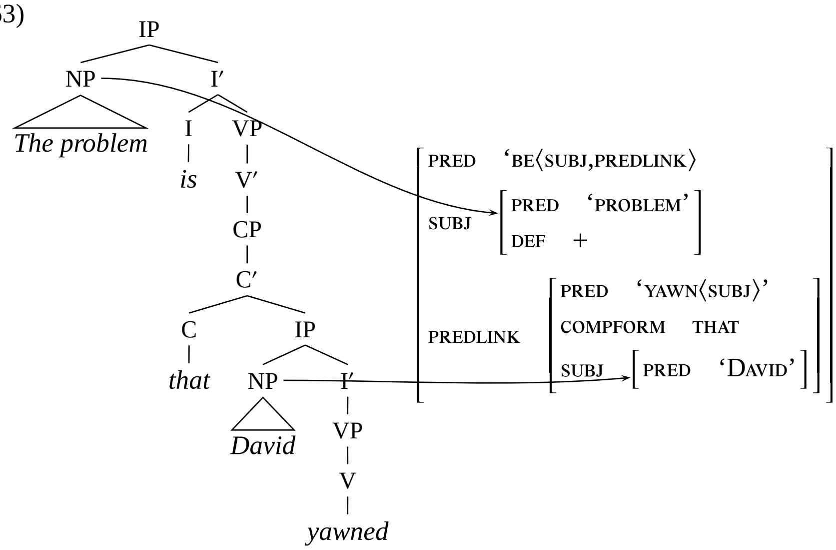
4.5.3. A Unified Analysis?

Determining which analysis is appropriate for copular constructions is a key issue. Some researchers adopt a unified approach to the f-structure of copular constructions: Butt et al. (1999) reject an XCOMP analysis on the basis that the types of complement phrases that appear in copular constructions (NPs, APs and PPs) do not usually select for a subject, and propose a unified double-tier analysis of copular constructions in which the complement phrase bears the closed function PREDLINK. Attia (2008) also argues for a unified f-structure analysis of copular constructions, stating that the apparent variation in copular constructions must be regarded as a matter of encoding only, and therefore should not be taken as evidence of functional variation. For example, Attia (2008) states that the presence or absence of a copular verb is simply a matter of c-structure variation, the verb itself being semantically redundant, and as such should not correspond to a difference at f-structure. Rather, the functional equivalency of copular constructions should be captured at the level of f-structure through a unified analysis that also reflects the fundamental ways in which copular constructions differ from subject-verb constructions.

In those cases where a unified analysis is advanced, we must decide which of the possible approaches to f-structure represents the default for a copular construction. The double-tier closed complement PREDLINK analysis, exemplified in (163), is the most widely adopted unified analysis of copular constructions in the literature; see Butt et al. (1999), Attia (2008), Sulger (2009, 2011) and Dione (2012). Attia claims that a single-tier analysis may be motivated in exceptional cases, citing those discussed in Nordlinger and Sadler (2007). Nordlinger and Sadler (2007) themselves conclude on grounds of economy that a single-tier analysis should be regarded as the default for languages with only verbless copular constructions, though they do not argue for a unified analysis of all copular constructions.

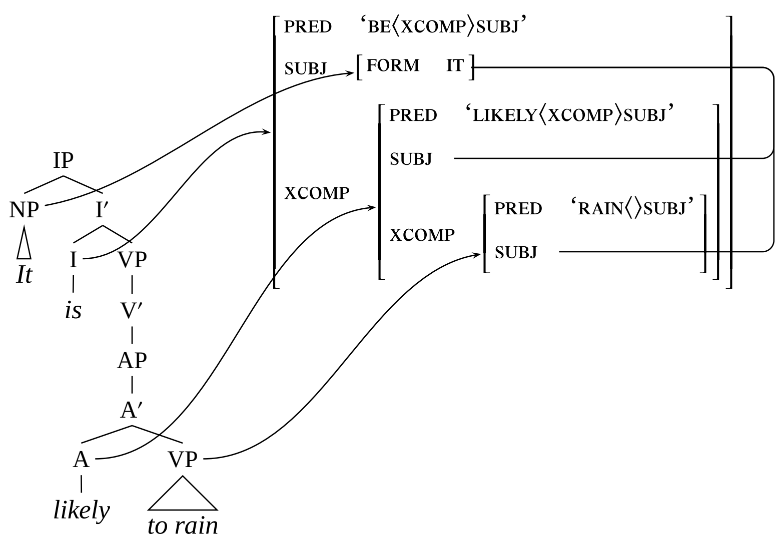
Other researchers have advocated an approach that allows more variation. Dalrymple et al. (2004a) observe that when the complement in a copular construction has a subject that is not the same as the one in the matrix clause, a single-tier analysis is not possible; the only possible analysis is one involving a closed grammatical function (they propose PREDLINK). This is because the SUBJ of the copular complement (*David* in 163) would clash with the SUBJ of the copula (*the problem* in 163), resulting in a violation of Consistency. If the main clausal PRED selects for a closed complement, however, the f-structure includes two distinct subjects and Consistency is respected, as shown in (163).

(163)



Compare (163) with (164), in which the (expletive) subject of the copula and its complement clause are the same. Dalrymple et al. (2004a) argue that in such cases an open complement XCOMP analysis is required to account for the fact that a standard control relation appears to exist between the two subjects (see Chapter 15 for a full discussion of open complements and control).

(164)



On the basis of examples such as (163) and (164), Dalrymple et al. (2004a) argue that a single analysis cannot apply to all copular constructions: whether a closed or open complement is involved must be determined on a case-by-case basis

— both crosslinguistically and within a single language — taking into account relevant syntactic properties, including the presence or absence of a copular verb and the presence or absence of agreement marking. On this view, the suitability of an analysis is determined independently for each copular construction, and the f-structures of all copular constructions need not be fundamentally the same, even within a single language. This approach to the analysis of copular constructions in LFG is also advocated by Falk (2004), Nordlinger and Sadler (2007), Laczkó (2012) and Lowe (2013).

Precisely how c-structure and f-structure are related in the case of copular constructions is the subject of ongoing debate in the LFG literature. Further research which considers data from a range of languages is required to determine if a unified analysis of some or all copular constructions is justified, either within a particular language or crosslinguistically.

5. FURTHER READING AND RELATED ISSUES

In Section 2.1, we treated agreement as specification of the features of the agreement target by the agreement controller. Haug and Nikitina (2016) present a typology of agreement analyses that encompasses other analytic possibilities, distinguishing *asymmetric* from *symmetric* analyses of agreement. Asymmetric analyses require the agreement features of the target to satisfy the agreement requirements of the controller, with the result that the controller must be fully specified for the agreement features that are present on the target; in contrast, according to the symmetric view, the controller and target cospecify the features involved in agreement, and underspecification is allowed in both the target and controller. Haug and Nikitina also distinguish *feature sharing* analyses from analyses not involving feature sharing: on a syntactic feature sharing analysis, the controller and target each bear a separate set of agreement features which must be compatible, while on a non-feature-sharing analysis, the target constrains the agreement features of the controller. The analysis we assume in this book is a symmetric analysis with no feature sharing, as is the analysis of Bresnan et al. (2016). Haug and Nikitina (2016) present arguments for a symmetric analysis with feature sharing, where the controller and the target each bear agreement features which are required to match, and Alsina and Vigo (2014) present arguments for a similar approach to the analysis of copular agreement in Catalan. Wechsler (2015) provides a useful overview of agreement patterns and the features that are relevant for agreement.

In the agreement patterns we examine in this book, the target of agreement is a predicate, and the controller is an argument of the predicate: for example, the target of agreement is often a verb, and the controller is its subject and/or object. More complex patterns are also found: see in particular Sadler (2016) for discussion and an LFG-based analysis of the very complex agreement patterns in Archi. Belyaev (2013) presents an Optimality Theory-based analysis of complex cross-dialectal verb agreement patterns in Dargwa involving different controllers of person agreement on the verb.

The formal tools and notational conventions of LFG presented in this and the next chapter are discussed in detail by Kaplan and Maxwell (1996) and Crouch et al. (2008).

6

SYNTACTIC RELATIONS AND SYNTACTIC CONSTRAINTS

Chapter 5 discussed ways of describing and constraining constituent structures and functional structures. This chapter continues that thread, introducing additional relations and constraints on structures. For most readers, this chapter best serves as a reference to be consulted for definition and discussion of concepts and relations that are used in the analyses presented in the remainder of the book.

1. REGULAR EXPRESSIONS AND REGULAR LANGUAGES

In formal language theory, a “language” is defined as a set of strings of symbols, sounds, letters, words, or whatever objects are of interest, and the “alphabet” is the set of minimal units that make up the strings. For instance, (1) shows a simple language over the alphabet $\{a, b\}$, containing seven strings:

(1) $\{a, b, ab, aaab, bbbbb, ababab, bbbaaa\}$

A class of languages with particularly simple formal properties is the class of *regular languages*, which are languages that can be characterized by *regular expressions*. In an LFG setting, regular expressions play an important formal role in the expression of constraints on both the c-structure and the f-structure. In

Chapter 5, Section 1.1, we saw that the right-hand side of an LFG phrase structure rule is a regular expression over c-structure categories, allowing disjunction, optionality, and repetition:

(2) $\text{V}' \longrightarrow \text{V (NP) PP}^*$

As we will see in Section 1.2, *functional uncertainty* involves characterization of paths through the f-structure by means of regular expressions over grammatical functions. Here, we provide a brief synopsis of regular languages and regular expressions and their use in formulating c-structural and f-structural constraints. For a detailed explication, see Partee et al. (1993, Section 17.2).

Formally, a regular expression is formed in the following way:

(3) a. The symbol ϵ or a single symbol is a regular expression. The symbol ϵ denotes the empty string.

b. The disjunction of two regular expressions $R1$ and $R2$, written $\{R1 \mid R2\}$, is a regular expression. The regular language denoted by the disjunction $\{R1 \mid R2\}$ is the union of the language $R1$ and the language $R2$: that is, all of the strings in $R1$ as well as all of the strings in $R2$.

c. Parentheses indicate optionality; if R is a regular expression, (R) denotes the union of the strings in R with the empty string, which could also be written as $\{R \mid \epsilon\}$.

d. The concatenation of two regular expressions $R1$ and $R2$, written $R1\, R2$, is a regular expression. The regular language denoted by $R1\, R2$ is the concatenation of the strings in $R1$ with the strings in $R2$. (The concatenation of *a* with *ab* is *aab*, and the concatenation of *aa* with *bb* is *aabb*.)

e. A regular expression annotated with the *Kleene star operator* $*$ is a regular expression. The regular expression R^* denotes the set of strings with 0 or more repetitions of the strings in R.

f. A regular expression annotated with the *Kleene plus operator* $+$ is a regular expression. The regular expression R^+ denotes the set of strings with 1 or more repetitions of the strings in R.

Groupings of symbols can be represented by enclosing the symbol in square brackets, which otherwise have no meaning.

Given these rules, the regular expression in (4a) is wellformed, and characterizes the regular language in (4b) (an *a*, followed by an optional *a*, followed by either *a* or *b*).

(4) a. Regular expression: $a(a)\{a|b\}$

b. Regular language: $\{aa, ab, aaa, aab\}$

The use of the Kleene star operator allows the description of an infinite language, since an expression such as R^* denotes a language in which the strings in R are repeated any number of times (including zero). The language characterized by the regular expression in (5a) consists of strings which begin with *a*, then contain any number of sequences of *bc* (including none), and end with *d*.

(5) a. Regular expression: $a[bc]^*d$

b. Regular language: $\{ad, abcd, abcbcd, abcbcbcd, abcbcbcbcd, ...\}$

Additionally, regular languages are closed under the set-theoretic operations of union and intersection, and regular languages over simple symbols such as phrase structure category labels and names of grammatical functions are closed under complementation.[1] In other words, the union or intersection of two regular languages is also a regular language, and the complement of a regular language whose alphabet consists of constituent structure categories or grammatical functions is also a regular language. Since this is true, regular languages can also be defined in terms of these operators. We can also define the *term complement* of a collection of symbols *s* as any of the symbols in the alphabet other than those in *s*.[2] For example, given the category labels discussed in Chapter 3, the term complement of NP is any category label other than NP, such as P, V′, or AdvP. The *relative difference* operator $-$ is similar: $A - B$ is the set of strings that are in *A* and are not in *B*. Thus, we can define the term complement of a single symbol or disjunction of single symbols *s* as $\Sigma - s$ (all symbols in the alphabet except for those in *s*), using the relative difference operator. It is common to use a special notation for union, intersection, and complementation of regular languages, different from the notation usually used for sets. We use the following notation for operations involving regular languages:

(6)

Union of two regular languages *A* and *B*:	$\{A \mid B\}$
Intersection of two regular languages *A* and *B*:	$A \,\&\, B$
Relative difference between two regular languages *A* and *B*:	$A - B$
Complement of the regular language *A*:	$\neg A$
Term complement of a collection of symbols *s*:	$\backslash s$

Care must be taken when defining the term complement of an annotated phrase structure category: the term complement of an annotated category C with annotation A denotes the set of all category/f-structure pairs that do not match the annotated category. This is the disjunction of \C (that is, any category other than C, with any annotation) and the category C with the annotation ¬A. For example, the term complement of the category NP with annotation (↑ SUBJ)=↓ is written as in (7a), and is the same as the disjunction in (7b).

[1] For definitions of union, intersection, and complementation, see (46) in this chapter (page 230). It is not currently known whether arbitrary regular languages over *annotated* phrase structure categories, associated with f-structure constraints such as ↑=↓ or (↑ SUBJ)=↓, are closed under complementation (Ron Kaplan, p.c.).

[2] Given an alphabet Σ, the universe (the set of all possible strings in the language) is Σ^*, and the complement of a set of strings S is $\Sigma^* - S$ (all strings in the universe except for those in S).

(7) a. $\backslash\left[\begin{array}{c}\text{NP}\\ (\uparrow \text{SUBJ}) = \downarrow\end{array}\right]$

b. $\{\backslash\text{NP} \mid \begin{array}{c}\text{NP}\\ (\uparrow \text{SUBJ}) \neq \downarrow\end{array}\}$

1.1. Regular Languages and Rule Descriptions

The ID/LP rule format discussed in Chapter 5, Section 1.5 allows the decomposition of a standard phrase structure rule into two aspects so that dominance constraints can be specified separately from precedence constraints. For example, the ID (immediate dominance) rule in (8a) licenses a c-structure tree in which a V′ node dominates two nodes, one labeled V and one labeled NP, but without specifying an order between V and NP. The LP (linear precedence) constraint in (8b) specifies that the V node precedes the NP node. This is a particular instance of the general rule in (8c), stating that a lexical (X) node must precede a phrasal (YP) node.

(8) a. $\text{V}' \longrightarrow \text{V, NP}$

b. V<NP

c. X<YP

This is an example of the use of a formal device, the ID/LP rule format, to express a generalization about word order across classes of phrase structure rules: for example, whether the phrases in a language are head-initial or head-final, or whether the specifier of a phrase precedes or follows the head.

More generally, it is possible to write rules that combine different constraints on phrasal structure, allowing for the succinct expression of linguistic generalizations about the structure of phrases. Such generalizations can be expressed in terms of separate constraints that must be simultaneously satisfied. Formally, this is possible because we are allowed to specify any regular language as the right-hand side of a phrase structure rule; this means that concatenation, disjunction, Kleene star, Kleene plus, intersection, and term complement can be used in specifying sequences of categories.

We have already seen that disjunctions over various possibilities for phrase structure expansion can be specified:

(9) $\text{X} \longrightarrow \{\ \text{Y1 Y2 Y3} \mid \text{Z1 Z2 Z3}\ \}$

This schematic rule indicates that a phrase with category X dominates either the series of daughters Y1 Y2 Y3 or the series Z1 Z2 Z3. As we have seen, disjunction in a phrase structure rule corresponds to the union of two regular languages, since the union of two regular languages encompasses all of the alternatives in each language.

Intersection of two regular languages corresponds to the combination of two descriptions; each description must hold of the result:

(10) X $\longrightarrow$ X1 & X2

This schematic rule indicates that X dominates a sequence of categories that must satisfy the description represented by X1 as well as the description represented by X2. Formally, this corresponds to characterizing a regular language by intersecting two regular languages, represented by X1 and X2.

To take a concrete example, we can restate ID/LP rules in this way. Consider the following simple rule:

(11) C′ $\longrightarrow$ C, IP   C<IP

We can think of the ID part of the rule, indicating dominance relations, as representing one aspect of the constraints on phrasal configurations. The ID rule in (11) can be expressed in an equivalent but much less revealing way as

(12) C′ $\longrightarrow$ {C IP | IP C}

That is, C′ dominates either C IP or IP C; the order is not determined.

The LP constraint C<IP is a requirement for C to precede IP, and this constraint can be imposed on any ID rule involving any number of categories. In its most general formulation, it can be written as a regular expression as follows (Ron Kaplan, p.c.):

(13) $([\backslash \mathrm{IP}]^{*}\ \mathrm{C})\ \ \backslash[\mathrm{C}|\mathrm{IP}]^{*}\ \ (\mathrm{IP}\ [\backslash \mathrm{C}]^{*})$

This expression allows any sequence of categories, including C, IP, and other categories, but with constraints on the relative order of C and IP. The expression takes advantage of the term complement operator: for example, \IP is any category except IP. Each of the members of the set of strings in the language of this expression consists of three parts. First, there is an optional sequence beginning with any number of categories not including IP and ending in C; next, there is a sequence of categories that does not contain either IP or C; finally, there is an optional sequence of categories that begins with IP and continues with a sequence not including C. In other words, this expression disallows IPs before the final C, and also disallows Cs after the final IP.

Now that we have reformulated the right-hand side of the ID rule and the LP constraint as regular expressions, we can state the combination of the two by intersection. The ID/LP rule in (14a) is equivalent to the expression in (14b), where the set of strings characterized by the regular expression on the right-hand side of the rule in (11) is intersected with the set of strings characterized by the LP constraint in (13):

(14) a. C′ $\longrightarrow$ C, IP   C<IP

b. C′ $\longrightarrow$ {C IP | IP C} & $([\backslash \mathrm{IP}]^{*}\ \mathrm{C})\ \ \backslash[\mathrm{C}|\mathrm{IP}]^{*}\ \ (\mathrm{IP}\ [\backslash \mathrm{C}]^{*})$

This example illustrates two points. First, we can state constraints on constituent structure configurations by defining a sequence of daughter nodes in a phrase structure rule in terms of a regular expression. This is a powerful and general tool for the linguist to use in the description of phrase structure.

Second, this way of stating generalizations may not be the clearest or most revealing. Although the encoding of linguistic facts in terms of operators such as Kleene star, union, intersection, and term complement leads to a solid understanding of their underlying formal and computational properties, it may be preferable to devise a special notation for some common operations, since (as can be seen above, from the restatement of ID/LP rules in terms of the intersection of two regular languages) it may not be perspicuous or revealing to state these in terms of the standard notation of regular expressions: the ID/LP notation in (14a) is simpler and easier to understand than the expression in (14b), where a complex regular expression is defined.

Kaplan and Maxwell (1996) define and discuss some operators that allow for the compact expression of particular kinds of regular languages:

The "Ignore" operator: Using the Ignore operator, written as a forward slash / (Kaplan and Kay 1994), we can write a rule that allows for a category or a sequence of categories to be interspersed with the other categories:

(15) XP ⟶ [X1 X2 X3] / Cat

This rule can be read as: "XP dominates X1 X2 X3, ignoring occurrences of Cat." In other words, XP must dominate X1 and X2 and X3 in that order, and may also dominate any number of occurrences of Cat at any position. This rule is equivalent to the following rule, containing a more complicated regular expression:

(16) XP ⟶ Cat* X1 Cat* X2 Cat* X3 Cat*

The Ignore operator rule can be used to describe the appearance of parenthetical elements, elements that can be inserted before or after any phrasal constituent (see McCawley 1982).

The "Shuffle" operator: Using the Shuffle operator, represented as a comma, we can specify two different sequences of nodes, each of which appears in a particular order but which may be interspersed or "shuffled" with each other. For instance:

(17) XP ⟶ [X1 X2 X3], [Y1 Y2 Y3]

According to this rule, XP must dominate nodes labeled X1 X2 X3 and Y1 Y2 Y3. The relative order of the Xs and the Ys must be preserved, but no order is specified across these sequences. The effect of this rule is similar to an ID/LP rule (Chapter 5, Section 1.5) where an ordering is specified among the X daughters and among the Y daughters, but not between the Xs and the Ys.

The rule in (17) allows sequences like the following, since in each case X1 precedes X2 and X3 and X2 precedes X3, and similarly for the Ys:

(18) a. X1 X2 X3 Y1 Y2 Y3
b. X1 X2 Y1 X3 Y2 Y3

c. X1 Y1 X2 Y2 X3 Y3

d. Y1 X1 X2 Y2 X3 Y3

Any ordering between the Xs and the Ys is allowed, as long as the order X1 X2 X3 and the order Y1 Y2 Y3 are preserved. The regular expression corresponding to this rule is quite complex and will not be displayed.

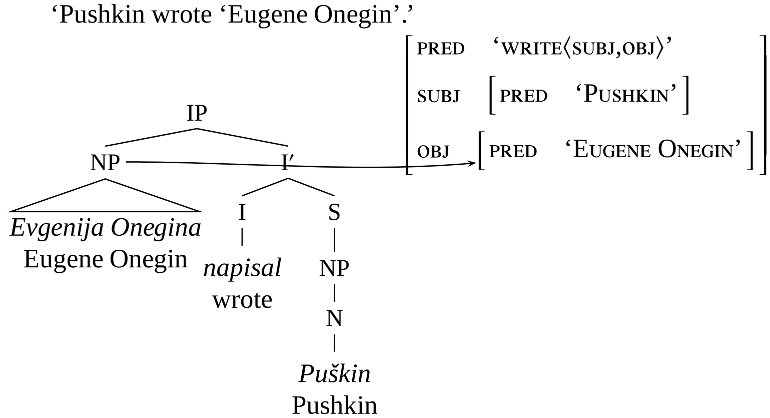
The Shuffle operator is used to characterize constraints involving partial orders holding among constituents in languages with otherwise fairly free word order. It has been proposed within the Head-Driven Phrase Structure Grammar framework by Reape (1994) in his analysis of word order in German; however, the phenomena Reape analyzes using Shuffle are best analyzed within LFG in terms of functional syntactic relations, as shown by Kaplan and Zaenen (1989b).

Other operators based on regular predicates can be proposed if their use simplifies linguistic description. The use of these operators assists the linguist in developing firm intuitions about linguistic phenomena; as long as the operators are definable in terms of regular predicates, no new formal power is added to the theory.

1.2. Regular Languages and Functional Uncertainty

Regular languages are also used in stating f-structural constraints. As discussed in Chapter 4, Section 2.3.2, an information-structurally prominent phrase bearing some grammatical function within the clause can appear in the specifier position of IP in Russian (King 1995, page 206):

(19) *'Evgenija Onegina' napisal Puškin.*
Eugene Onegin wrote Pushkin
'Pushkin wrote 'Eugene Onegin'.'



The specifier of IP in Russian is not associated with any particular grammatical function. Here the phrase in the specifier of IP, *Evgenija Onegina*, bears the OBJ function; in other examples, a phrase in the same position might be the SUBJ or an oblique. This *functional uncertainty* about the grammatical function of a phrase in this position can be represented by defining a special abbreviatory symbol GF representing a disjunction of all grammatical functions, similar to the definition of GGF for governable grammatical functions:[3]

(20) $\text{GF} \equiv \{\text{SUBJ} \mid \text{OBJ} \mid \text{OBJ}_\theta \mid \text{COMP} \mid \text{XCOMP} \mid \text{OBL}_\theta \mid \text{ADJ} \in \mid \text{XADJ} \in\}$

This definition uses the set membership symbol $\in$ as an attribute to allow reference to some member of a set, as discussed in Chapter 6, Section 3.1.

The abbreviatory symbol GF appears in the phrase structure rule for IP in Russian (following King 1995, page 204):

(21) $\text{IP} \longrightarrow \begin{pmatrix} \text{XP} \\ (\uparrow \text{GF}) = \downarrow \end{pmatrix} \begin{pmatrix} \text{I}' \\ \uparrow = \downarrow \end{pmatrix}$

An equation such as $(\uparrow \text{GF}) = \downarrow$ is satisfied if there is some value of GF for which the equation is true. Here, the equation is true if the value of GF is OBJ.

In this instance, the uncertainty was limited: one member of a disjunction of grammatical functions was chosen (based, at least, on world knowledge of the relation between an author and a book). In other cases, there might be more uncertainty; the phrase might bear a grammatical function more deeply embedded inside the sentence. This is true for constituent questions in English. Example (22) shows that the question phrase *what* can fill the role of OBJ in the complement clause COMP, appearing as the value of the path COMP OBJ in the f-structure (for clarity, the attributes making up the path are enclosed in boxes). In (23), which involves another complement clause, it is the value of the path COMP COMP OBJ.

---

[3]Recall the definition of GGF given in Chapter 5, Section 4, (134):

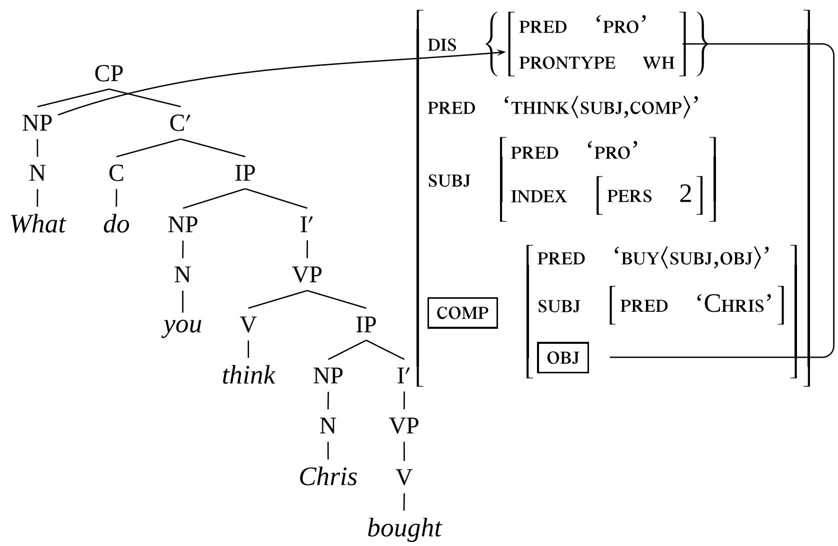
(a) $\text{GGF} \equiv \{\text{SUBJ} \mid \text{OBJ} \mid \text{OBJ}_\theta \mid \text{COMP} \mid \text{XCOMP} \mid \text{OBL}_\theta\}$

Relying on this definition of GGF, we can provide an alternative, more succinct definition of GF as a disjunction over members of the ADJ and XADJ set and the governable grammatical functions:

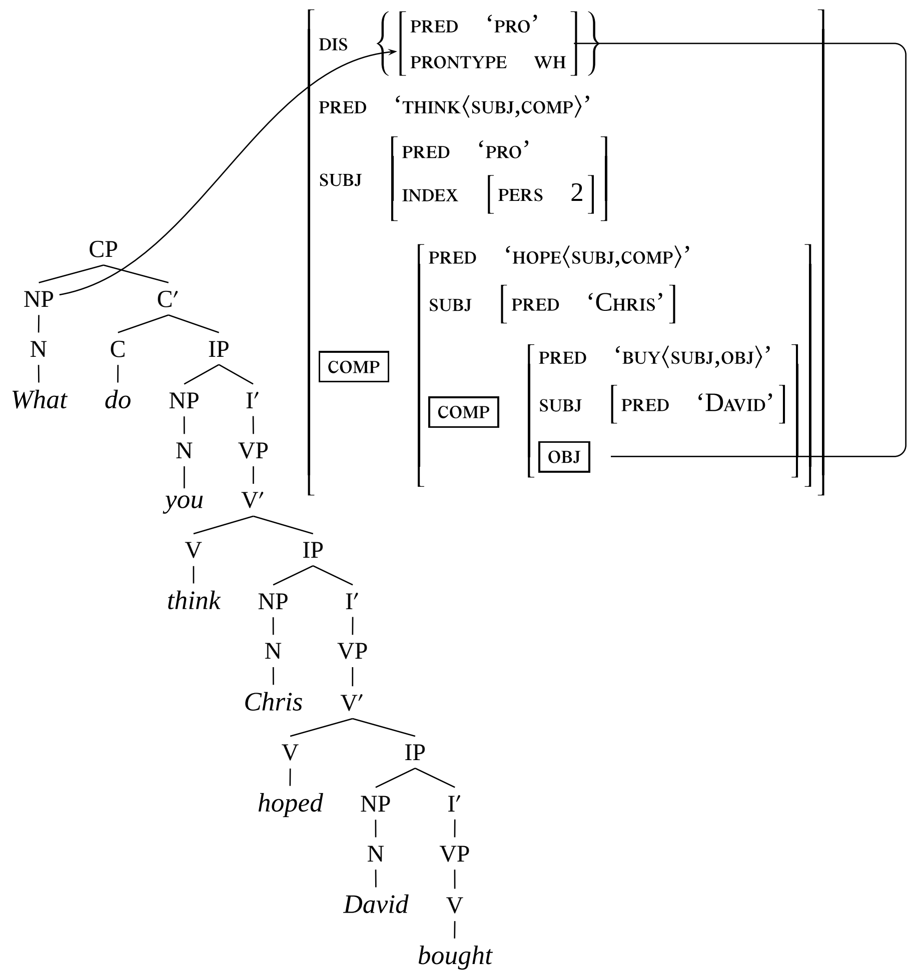
(b) $\text{GF} \equiv \{\text{GGF} \mid \text{ADJ} \in \mid \text{XADJ} \in\}$

The definitions in (b) and (20) are exactly equivalent.

(22) *What do you think Chris bought?*



(23) *What do you think Chris hoped David bought?*



A simplified version of the annotated phrase structure rule for English constituent questions is:

(24) $$\text{CP} \longrightarrow \begin{pmatrix} \text{XP} \\ \downarrow\in(\uparrow \textsc{dis}) \\ (\uparrow \textsc{comp}^{*}\ \textsc{gf})=\downarrow \end{pmatrix} \begin{pmatrix} \text{C}' \\ \uparrow=\downarrow \end{pmatrix}$$

The first annotation on the XP daughter of CP, $\downarrow\in(\uparrow \textsc{dis})$, requires the f-structure corresponding to the XP to be a member of the set value of the DIS attribute of the CP mother node. The second annotation on the XP node, $(\uparrow \textsc{comp}^{*}\ \textsc{gf})=\downarrow$, contains a new sort of expression. As discussed in Section 1, the Kleene star operator * indicates that an expression may be repeated zero or more times. In particular, $\textsc{comp}^{*}$ represents paths containing any number of COMPs: the empty path, COMP, COMP COMP, and so on. Thus, the equation $(\uparrow \textsc{comp}^{*}\ \textsc{gf})=\downarrow$ indicates that within the f-structure $\uparrow$, the DIS f-structure also bears some grammatical function GF which lies at the end of some path in the set of paths COMP*: that is, some GF that may be embedded inside any number of COMPS. The constraint holds if there is some path in the set of paths COMP* GF for which the equation is true. In (22), the path is COMP OBJ. In (23), the path is COMP COMP OBJ. In some other example, a different path might be chosen.

More complicated paths can also be characterized. A slightly more complete version of the rule for question formation in English is:

(25) $\text{CP} \longrightarrow \begin{pmatrix} \text{XP} \\ \downarrow \in (\uparrow \text{DIS}) \\ (\uparrow \{\text{XCOMP}|\text{COMP}\}^* \ \text{GF}) = \downarrow \end{pmatrix} \begin{pmatrix} \text{C}' \\ \uparrow = \downarrow \end{pmatrix}$

The regular expression {XCOMP|COMP}* denotes paths containing any number of XCOMPS or COMPS in any order: for example, COMP XCOMP, COMP COMP, or XCOMP COMP XCOMP.[4]

Equations of this sort, involving abbreviatory symbols over grammatical functions or more complex regular expressions denoting paths through an f-structure, exemplify *functional uncertainty*. Functional uncertainty was first introduced by Kaplan et al. (1987) and Kaplan and Zaenen (1989b) in the treatment of *long-distance dependencies* such as topicalization, question formation, and relative clause formation in English. The expression in (25) more adequately captures constraints on question formation in English than the one in (24), but still does not completely characterize the possible grammatical functions which can be borne by the sentence-initial DIS constituent in English questions; a detailed discussion of the syntax and semantics of long-distance dependencies is provided in Chapter 17.

Definition (30) in Chapter 5, repeated in (26), tells us how to interpret constraints involving a string *as* of length greater than one:

(26) $(f\ as) \equiv ((f\ a)\ s)$ for a symbol a and a string of symbols s.

$(f\ \epsilon) \equiv f$, where ϵ is the empty string.

For instance, the f-structure (f COMP SUBJ) is the f-structure at the end of the path COMP SUBJ within the f-structure f; it is the same as ((f COMP) SUBJ), the SUBJ of the f-structure (f COMP). In (26), the string s is the suffix of the string as.

Building on this definition, Kaplan and Zaenen (1989b) provide the following interpretation for constraints involving regular expressions over paths:

(27) Functional uncertainty:

If α is a regular expression, then $(f\ \alpha) = v$ holds if and only if

$$(f\ a\ \text{SUFF}(a, \alpha)) = v$$

for some symbol a, where $\text{SUFF}(a, \alpha)$ is the set of suffix strings s such that $as \in \alpha$.

[4]Note that this expression is not the same as the regular expression {XCOMP* | COMP*} which denotes paths containing *either* any number of XCOMPS *or* any number of COMPS: XCOMP XCOMP XCOMP or COMP COMP, but not XCOMP COMP.

The definition in (27) is stated with reference to the predicate SUFF, which takes two arguments: a string *a* and a regular language α, a set of strings composed of grammatical functions. SUFF(a, α) is the set of strings which are possible continuations of *a* in the regular language α. For example:

(28) If α is the regular language

{COMP SUBJ, COMP COMP SUBJ, COMP COMP COMP SUBJ, COMP XCOMP OBJ}

then SUFF(COMP COMP, α) is the set of strings that follow the string COMP COMP in α:

{SUBJ, COMP SUBJ}

According to the definition in (27), then, we interpret a constraint involving a regular expression by making a series of left-to-right choices: that is, by choosing a symbol *a* that is the first symbol in some string in α, and then choosing a wellformed continuation of *a* in α, SUFF(a, α).

Much work has been done on the formal properties of systems using functional uncertainty. For an overview discussion, see Dalrymple et al. (1995d). The issue of decidability and functional uncertainty is treated in detail by Kaplan and Maxwell (1988a), Baader et al. (1991), Backofen (1993), and Keller (1993).

1.3. Inside-Out Functional Uncertainty

By using functional uncertainty, we can specify an f-structure embedded at an arbitrary depth inside another f-structure. We can also talk about f-structures that *enclose* an f-structure at an arbitrary level of distance. This is referred to as *inside-out functional uncertainty*, first introduced by Kaplan (1988). The two types of functional uncertainty are closely related, but they are used in different contexts: "ordinary" outside-in functional uncertainty is used to define constraints on more deeply embedded structures, while inside-out functional uncertainty is used to define constraints on enclosing structures.

Inside-out functional uncertainty is used by Nordlinger (1998, 2000) in her theory of *constructive case*. Consider the following Wambaya example (Nordlinger 1998, page 65):

(29) *Dawu gin-a alaji janyi-ni.*
bite 3SG.M.SUBJ-PST boy.M.ACC dog.M-ERG
'The dog bit the boy.'

The noun *janyi-ni* 'dog.M-ERG' bears an ERGative marker *-ni*, signaling its grammatical function: nouns marked with ERGative case are subjects. According to Nordlinger's theory of constructive case, casemarking specifies the syntactic environment within which the casemarked phrase must appear. The f-structure corresponding to the noun dominating *janyi-ni* is:

(30)
$$d\begin{bmatrix} \text{PRED} & \text{`DOG'} \\ \text{INDEX} & \begin{bmatrix}\text{GEND} & \text{M}\end{bmatrix} \\ \text{CONCORD} & \begin{bmatrix}\text{CASE} & \text{ERG}\end{bmatrix} \end{bmatrix}$$

According to Nordlinger's rules for constructive case in Wambaya, this f-structure must appear in the following f-structure environment:

(31)
$$b\begin{bmatrix} \text{SUBJ} & d\begin{bmatrix} \text{PRED} & \text{`DOG'} \\ \text{INDEX} & \begin{bmatrix}\text{GEND} & \text{M}\end{bmatrix} \\ \text{CONCORD} & \begin{bmatrix}\text{CASE} & \text{ERG}\end{bmatrix} \end{bmatrix} \end{bmatrix}$$

In (31), the f-structure for *janyi-ni* is the one labeled d; it is required to bear the SUBJ relation within its clause. Nordlinger enforces this requirement by means of the following lexical entry for *janyi-ni*:

(32) *janyi-ni* $(\uparrow \text{PRED}) = \text{`DOG'}$
$(\uparrow \text{INDEX GEND}) = \text{M}$
$(\uparrow \text{CONCORD CASE}) = \text{ERG}$
$(\text{SUBJ} \uparrow)$

The first three equations state that the f-structure for *janyi-ni* must have a PRED with value 'DOG', the value M for its GEND attribute, and the value ERG for its CASE attribute, as shown in (30). The expression $(\text{SUBJ} \uparrow)$ in the fourth line of this lexical entry is different from the other expressions in (32), in that the attribute SUBJ appears to the left of the f-structure designator $\uparrow$. This inside-out expression refers to an f-structure through which the path SUBJ leads to the f-structure $\uparrow$; this is the outermost f-structure, labeled b, in (31). In (32), this expression is an *existential constraint* (see Chapter 5, Section 2.6) requiring such an f-structure to exist.

Formally, $(a\ f)$ is the f-structure whose value for the attribute a is f:

(33) Inside-out expression:

$(a f) = g$ holds if and only if g is an f-structure, a is a symbol, and the pair $\langle a, f\rangle \in g$.

In (32), the inside-out functional uncertainty path consists of just one attribute, SUBJ. Longer paths in an inside-out equation are interpreted incrementally, as with outside-in expressions (see Chapter 5, Section 2.1).

(34) $(\epsilon\ f) = f$, where ϵ is the empty string.

$(sa f) = (s\ (a\ f))$ for a symbol a and a string of symbols s.

As with outside-in functional uncertainty, it is possible to use a regular expression to characterize a set of paths through the f-structure. This will be useful in our analysis of anaphora, to be presented in Chapter 14. The use of regular expressions in inside-out functional uncertainty is similar to its use in outside-in functional uncertainty: the expression is true if there is some string in the set of strings picked out by the regular expression for which the expression holds.

(35) Inside-out functional uncertainty:

$(\alpha\ f) \equiv g$ if and only if g is an f-structure, α is a set of strings, and for some s in the set of strings α, $(s\ f) \equiv g$.

Notice that even when the inside-out path is fixed and the expression containing it appears to be determinate, it may denote any of several f-structures. Consider the f-structure in (37) for a verb like *seem*, whose subject is shared with the subject of its open infinitival complement according to the lexical entry in (36) (see Chapter 15 for a discussion of verbs taking an open complement XCOMP):

(36) *seem* $(\uparrow \textsc{pred}) = \text{`}\textsc{seem}\langle\textsc{xcomp}\rangle\textsc{subj}\text{'}$
$(\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj})$

(37) *David seemed to yawn.*

$$s\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{seem}\langle\textsc{xcomp}\rangle\textsc{subj}\text{'} \\ \textsc{subj} & d\left[\begin{array}{ll} \textsc{pred} & \text{`David'} \end{array}\right] \\ \textsc{xcomp} & y\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'} \\ \textsc{subj} & \end{array}\right] \end{array}\right]$$

In (37), the f-structure for *David*, labeled d, is the SUBJ of two f-structures: the f-structure for *seem*, labeled s, and the f-structure for *yawn*, labeled y. In this case, we can construct an inside-out expression rooted in the f-structure d, (SUBJ d), which refers to either of the two f-structures of which d is the SUBJ: (SUBJ d) is either s or y.

2. THE PCASE ATTRIBUTE

The grammatical function of an oblique PP argument is determined in English by the preposition that is used. For example, the goal phrase *to Chris* in a sentence like *David gave the book to Chris* bears the grammatical function $\textsc{obl}_{\textsc{goal}}$. As discussed in Chapter 2, Section 5.4, Kaplan and Bresnan (1982) propose that the constraint specifying the grammatical function of an oblique phrase is given by the preposition. In this case, the information that *to Chris* is an $\textsc{obl}_{\textsc{goal}}$ is specified as the value of the PCASE attribute in the lexical entry of the preposition *to*:[5]

(38) *to* $(\uparrow \textsc{pcase}) = \textsc{obl}_{\textsc{goal}}$

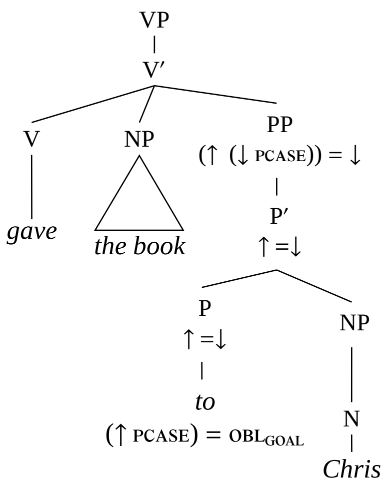
[5]Kaplan and Bresnan's analysis prefigures Nordlinger's (1998) theory of *constructive case*, discussed in Section 1.3, according to which the grammatical function of an argument is specified by the case morpheme with which it appears.

Kaplan and Bresnan further propose that the value of the PCASE attribute is also the attribute whose value is the oblique phrase, so that OBL_{GOAL} is an attribute name as well as a value. The following annotation on the PP phrase structure node accomplishes this:

(39)
$$\begin{array}{c}\text{PP}\\(\uparrow\ (\downarrow\ \text{PCASE})) = \downarrow\end{array}$$

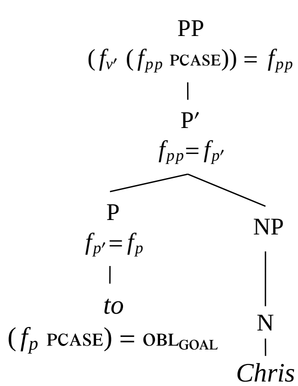
This annotation appears as a part of the rule expanding V′. The full expansion of the V′ node is as follows:

(40) *gave the book to Chris*



Using mnemonic names for f-structures, such as f_{pp} for the f-structure corresponding to the PP node in the c-structure tree, the equations in (40) for the PP and the nodes it dominates are instantiated as in (41):

(41)



The relevant f-description is the following:

(42) $$\begin{array}{l} (f_{v'}\ (f_{pp}\ \textsc{pcase})) = f_{pp} \\ f_{pp} = f_{p'} \\ f_{p'} = f_{p} \\ (f_{p}\ \textsc{pcase}) = \textsc{obl}_{\textsc{goal}} \end{array}$$

These equations tell us that the f-structure f_{pp} corresponding to the PP node is the same as the f-structures $f_{p'}$ and f_p corresponding to the P′ and P nodes, and that f_p's PCASE is $\textsc{obl}_{\textsc{goal}}$. Thus, we have the following equivalences:

(43) $$(f_{pp}\ \textsc{pcase}) = (f_{p'}\ \textsc{pcase}) = (f_{p}\ \textsc{pcase}) = \textsc{obl}_{\textsc{goal}}$$

Substituting $\textsc{obl}_{\textsc{goal}}$ for $(f_{pp}\ \textsc{pcase})$ in the first equation in (42), we have:

(44) $$(f_{v'}\ \textsc{obl}_{\textsc{goal}}) = f_{pp}$$

The equality induced by the constraint in (44) is explicitly indicated by a line in this f-structure:

(45) $$f_{v'}\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{give}\langle \textsc{subj},\textsc{obj},\textsc{obl}_{\textsc{goal}}\rangle\text{’} \\ \textsc{obl}_{\textsc{goal}} & f_{pp}, f_{p'}, f_{p}\begin{bmatrix} \textsc{pred} & \text{‘Chris’} \\ \textsc{pcase} & \textsc{obl}_{\textsc{goal}} \end{bmatrix} \end{bmatrix}$$

3. TALKING ABOUT SETS

Sets are used to represent several different types of objects in LFG. Primarily, sets are used where an unbounded number of elements is in principle allowed: for coordinate structures, for example, where there is no fixed limit to the number of conjuncts; or for the modifiers of a phrase, where any number of modifiers may appear. In the following, we discuss ways of describing sets and constraining their members. We first provide definitions for the standard symbols which are used in talking about sets and relations between them.

(46) $\in$ Set membership. $a \in S$ means that a is a member of the set S.

$\notin$ Negated set membership. $a \notin S$ means that a is not a member of the set S.

$\subseteq$ Subset. $A \subseteq B$ means that A is a subset of B: that is, all of the members of A are also members of B. If A is a subset of B and vice versa ($A \subseteq B$ and $B \subseteq A$), then $A = B$.

$\subset$ Proper subset. $A \subset B$ means that A is a proper subset of B: that is, all of the members of A are also members of B, and B has some additional members that are not in A.

$\cup$ Union. $A \cup B$ is the set which is the union of A with B, which is the result of combining the two sets. In other words, the union of set A

with set B contains all members of set A as well as all members of set B.

$\cap$ Intersection. $A \cap B$ is the set which is the intersection of A with B, which contains all of the members that A and B have in common.

$\emptyset$ The empty set, sometimes written as $\{\ \}$. $\emptyset$ is a set that has no members.

A' Set complement. In defining the *complement* (A') of a set A, we must make reference to the *universe*, which consists of all possible members of the set; the complement of a set A is then the set containing all of the elements in the universe that are not in A. For example, suppose that the universe is all of the letters in the Roman alphabet, and A is a set consisting of all strings containing any number of *a*s, including none ($\{\epsilon, a, aa, aaa, aaaa, ...\}$):[6] this is the set characterized by the regular expression a^*, as discussed in Section 1. The complement A' is, then, the set of all strings that contain any letter other than a.

3.1. Open Set Descriptions

An *open set description* is given by separately specifying the individual elements of a set. The constraints specifying the elements may be given in different parts of the grammar, by different phrase structure rules or lexical items. For example, consider the following rule for the English V′, in which we make the simplifying assumption that the verb is followed by a single NP object and any number of PP adjuncts:

(47) $$\text{V}' \longrightarrow \begin{pmatrix} \text{V} \\ \uparrow = \downarrow \end{pmatrix} \begin{pmatrix} \text{NP} \\ (\uparrow \textsc{obj}) = \downarrow \end{pmatrix} \begin{array}{c} \text{PP*} \\ \downarrow \in (\uparrow \textsc{adj}) \end{array}$$

The expression PP* represents a sequence of zero or more PPs. What about the annotation $\downarrow \in (\uparrow \textsc{adj})$? This annotation means that the f-structure of each PP that appears is an adjunct, and so is a member ($\in$) of the ADJ set of the mother's f-structure $\uparrow$. That is, there may be zero or more occurrences of the following annotated node:

(48) $$\begin{array}{c} \text{PP} \\ \downarrow \in (\uparrow \textsc{adj}) \end{array}$$

The expression in (49) represents an alternative way of specifying set membership:

(49) $$(\uparrow \textsc{adj} \in) = \downarrow$$

This expression uses the set membership symbol $\in$ as an *attribute* and states that $\downarrow$ is a member of the set $(\uparrow \textsc{adj})$. Expressions such as these are sometimes useful in stating constraints on set members, particularly in expressions involving

[6] Recall that ϵ is the empty string: see (3) in this chapter.

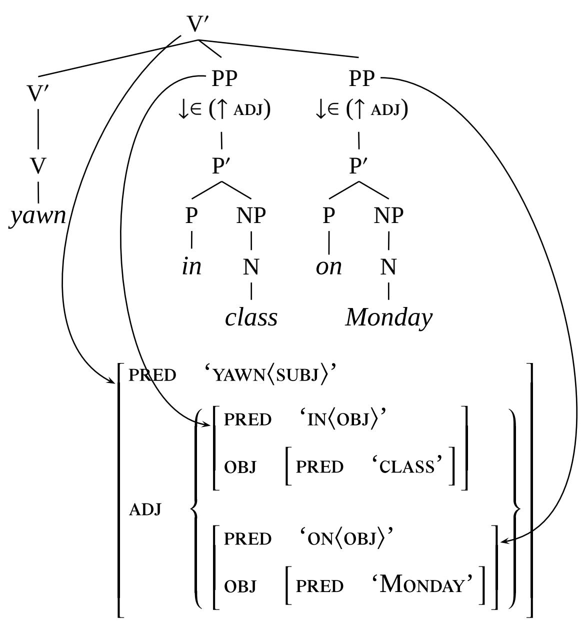
inside-out functional uncertainty, discussed in Section 1.3. The two expressions in (50) are equivalent; each states that the f-structure ↓ is a member of the set of f-structures (↑ ADJ):

(50) $\downarrow \in (\uparrow \text{ADJ})$

$(\uparrow \text{ADJ} \in) = \downarrow$

The c-structure and f-structure for a V′ like *yawn in class on Monday* are:

(51)



As the annotations on the rule require, the f-structure of each modifying adjunct PP is a member of the ADJ set of the f-structure for the mother V′ node.

Formally, an expression involving set membership is defined as we would expect:

(52) Open set description:

$g \in f$ holds if and only if f is a set and g is a member of f.

It is also possible to write a constraining expression for set membership:

(53) Constraining statement of set membership:

$g \in_c f$ holds if and only if f is a set and g is a member of f in the minimal solution for the defining equations in the f-description of f.

Rounds (1988) provides more discussion of the description and representation of sets in LFG.

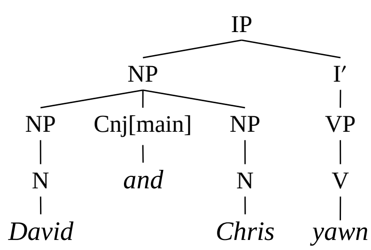
3.2. Distributive and Nondistributive Features

Sets are also used in the representation of coordinate structures, but in that case there is a difference: as explained in Chapter 2, Section 4.5, a set representing a coordinate structure is a *hybrid object* that can have its own attributes and values as well as having elements. This captures the fact that a coordinate structure such as *David and Chris* in an example like (54) has properties that the individual conjuncts do not have:

(54) *David and Chris yawn/*yawns.*

Although both *David* and *Chris* are singular phrases, the coordinate structure as a whole is plural. The c-structure and f-structure for such an example are:

(55) *David and Chris yawn.*



$$\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{yawn}\langle\textsc{subj}\rangle\text{’} \\ \textsc{subj} & \left[\begin{array}{l} \textsc{index}\ \left[\textsc{num}\ \ \textsc{pl}\right] \\ \left\{ \left[\begin{array}{ll} \textsc{pred} & \text{‘David’} \\ \textsc{index} & \left[\textsc{num}\ \ \textsc{sg}\right] \end{array}\right] \left[\begin{array}{ll} \textsc{pred} & \text{‘Chris’} \\ \textsc{index} & \left[\textsc{num}\ \ \textsc{sg}\right] \end{array}\right] \right\} \end{array}\right] \end{array}\right]$$

We present here a simplified, preliminary phrase structure rule for NP coordination; a more detailed discussion of coordination, including the complex category Cnj[main], can be found in Chapter 16:

(56)
$$\begin{array}{llccc} \text{NP} & \longrightarrow & \text{NP} & \text{Cnj[main]} & \text{NP} \\ & & \downarrow \in \uparrow & \uparrow = \downarrow & \downarrow \in \uparrow \\ & & & (\uparrow \textsc{index num}) = \textsc{pl} & \end{array}$$

As presented in (56), the annotations on the NP daughters require the f-structure for each conjunct NP to be a member of the f-structure for the coordinate NP. That is, the f-structure for the NP as a whole is a set, with the NP conjuncts as its members.

The annotation on the Cnj[main] daughter requires the coordinate structure to have an INDEX attribute whose value is a structure specifying plural number: the coordinate structure is a plural phrase. In other words, besides having the f-structures for *David* and *Chris* as members, the set representing the coordinate structure has the attribute INDEX whose value contains the attribute-value pair ⟨NUM, PL⟩, signifying plural number. What does it mean to specify a property of a set in this way?

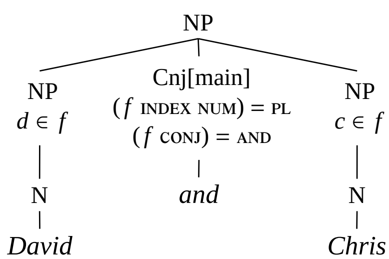
3.2.1. Nondistributive Features

In specifying a property of a set, the property may or may not *distribute* to the members of the set, depending on whether the feature involved is a *distributive* or a *nondistributive* feature. We classify the following features as nondistributive:

(57) Nondistributive features:
INDEX, ADJ, CONJ, PRECONJ

If a feature of a set is nondistributive, it is a property of the set as a whole. Thus, the CONJ and INDEX attributes and their values specified in the rule in (56) are a property of the coordinate structure as a whole, not the individual conjuncts:

(58) $(f\ \text{INDEX NUM}) = \text{PL}$ (INDEX is a nondistributive feature)
$(f\ \text{CONJ}) = \text{AND}$ (CONJ is a nondistributive feature)



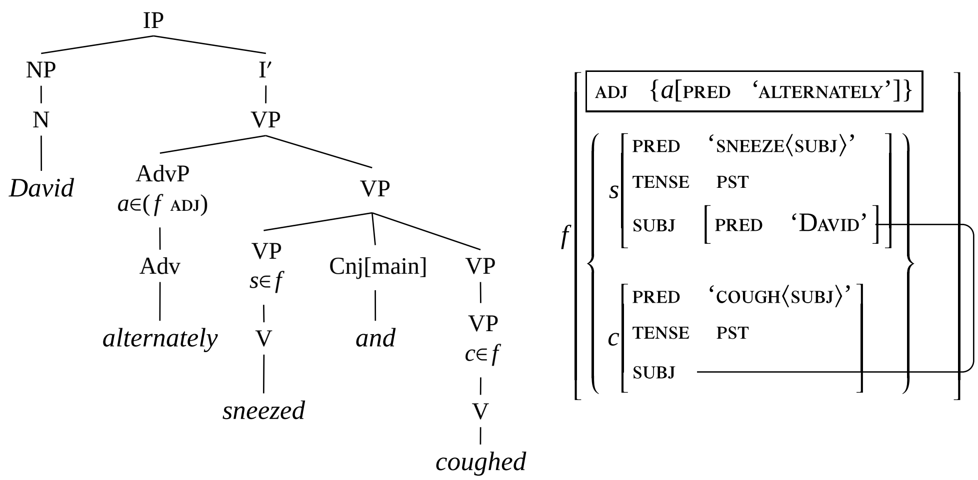
$$f\left[\begin{array}{l}\boxed{\begin{array}{ll}\text{INDEX} & [\text{NUM}\ \ \text{PL}]\\ \text{CONJ} & \text{AND}\end{array}}\\ \left\{\begin{array}{l} d\left[\begin{array}{ll}\text{PRED} & \text{‘DAVID’}\\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3\\ \text{NUM} & \text{SG}\end{array}\right]\end{array}\right]\\ c\left[\begin{array}{ll}\text{PRED} & \text{‘CHRIS’}\\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3\\ \text{NUM} & \text{SG}\end{array}\right]\end{array}\right]\end{array}\right\}\end{array}\right]$$

Modifiers can also modify a coordinate structure as a whole, and so the ADJ feature is also a nondistributive feature. For example, the adverb *alternately* in the sentence *David alternately sneezed and coughed* modifies the conjoined phrase *sneezed and coughed*: the sentence does not mean that David alternately sneezed and that he also alternately coughed, but that he alternated in performing the two actions. We assume the adjunction rule in (59), which adjoins an AdvP at the VP level, as well as the VP coordination rule in (60). Note that this example also shows that grammatical functions such as SUBJ are distributive attributes, since specifying the f-structure for *David* as the SUBJ of the coordinate phrase amounts to specifying that f-structure as the SUBJ of each conjunct (Chapter 16, Section 2), hence the link between the subjects in the f-structure in (61).

(59) $$\text{VP} \longrightarrow \underset{\downarrow \in (\uparrow\ \text{ADJ})}{\text{AdvP}} \quad \underset{\uparrow = \downarrow}{\text{VP}}$$

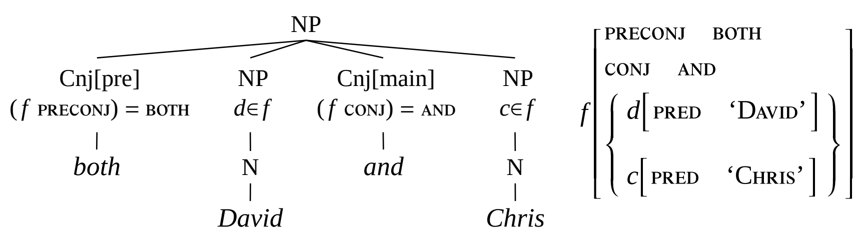
(60) $$\text{VP} \longrightarrow \underset{\downarrow \in \uparrow}{\text{VP}} \quad \underset{\uparrow = \downarrow}{\text{Cnj[main]}} \quad \underset{\downarrow \in \uparrow}{\text{VP}}$$

(61) $a \in (f$ ADJ$)$ (ADJ is a nondistributive feature)



We also classify the features CONJ and PRECONJ as nondistributive; as we discuss in Chapter 16, Section 3, the form of the conjunction and preconjunction are properties of the coordinate structure as a whole, not of the individual conjuncts. In an example like *Both Chris and David yawned*, the preconjunction *both* and the conjunction *and* contribute values for the CONJ and PRECONJ features of the coordinate phrase *both Chris and David*:

(62) $(f$ PRECONJ$=$ BOTH$)$ (PRECONJ is a nondistributive feature)
$(f$ CONJ$=$ AND$)$ (CONJ is a nondistributive feature)

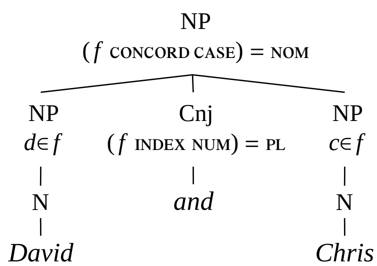


3.2.2. Distributive Features

In contrast, a distributive feature and its value are a property of each member of the set, not of the set as a whole. We assume that all features other than ADJ, INDEX, CONJ, and PRECONJ are distributive.

For example, suppose that CONCORD is classified as a distributive feature, and that we want to specify the CONCORD CASE of a particular coordinate phrase f as NOM. In this situation, specifying the set f as having a particular value for CONCORD means that each member of the set f — here, d and c — must be specified with that value for CONCORD:[7]

(63) $(f\ \text{CONCORD CASE}) = \text{NOM}$ (CONCORD is a distributive feature)



$$f\left[\begin{array}{l} \text{INDEX}\quad [\text{NUM}\ \ \text{PL}] \\ \left\{\begin{array}{l} d\left[\begin{array}{ll} \text{PRED} & \text{`DAVID'} \\ \text{INDEX} & [\text{NUM}\ \ \text{SG}] \\ \boxed{\text{CONCORD}\ \ [\text{CASE}\ \ \text{NOM}]} & \end{array}\right] \\ c\left[\begin{array}{ll} \text{PRED} & \text{`CHRIS'} \\ \text{INDEX} & [\text{NUM}\ \ \text{SG}] \\ \boxed{\text{CONCORD}\ \ [\text{CASE}\ \ \text{NOM}]} & \end{array}\right] \end{array}\right\} \end{array}\right]$$

When they are not features of sets, the behavior of distributive and nondistributive features is the same.

As features of sets, distributive and nondistributive features are formally treated in the following way (Dalrymple and Kaplan 2000):

(64) Distributive and nondistributive features:

If a is a *distributive* feature and s is a set of f-structures, then $(s\ a) = v$ holds if and only if $(f\ a) = v$ for all f-structures f that are members of the set s.

If a is a *nondistributive* feature and s is a set of f-structures, then $(s\ a) = v$ holds if and only if the pair $\langle a, v\rangle$ is in the set s itself.

3.3. Functional Uncertainty and Sets

In constraints involving functional uncertainty, a regular expression representing a path through the f-structure can be resolved differently in each conjunct of a coordinate structure. Kaplan and Maxwell (1988b) provide the definition in (27) of this chapter, repeated in (65):

(65) Functional uncertainty:

If α is a set of strings, then $(f\ \alpha) = v$ holds if and only if

$$(f\ a\ \text{SUFF}(a, \alpha)) = v$$

[7]Though CONCORD features such as CASE are often analyzed as distributive features, Peterson (2004a) and Hristov (2012, Chapter 5; 2013b) argue that CASE is best treated as a nondistributive feature in light of acceptable examples involving case mismatch. If CASE is distributive, case mismatch is not allowed, since any specification of the CASE value for the set as a whole applies to all of the conjuncts. See Chapter 2, Section 5.7.5 for further discussion.

for some symbol a, where SUFF(a, α) is the set of suffix strings s such that $as \in \alpha$.

As a consequence of this definition, if a functional uncertainty path involves a set, the path may unwind differently in each element of the set: a valid path must be taken within each element, but a different path may be taken for each element. We return to this point in Chapter 17, Section 1.1.1.

3.4. Closed Set Descriptions

A *closed set description* lists all of the elements of the set in a single constraint, instead of specifying the elements of the set by means of separate constraints mentioning each element. As discussed in Chapter 2, Section 5.7.2, Dalrymple and Kaplan (2000) use sets with atomic values to represent the values of attributes like PERS; we review their proposal here to illustrate closed set descriptions.

Dalrymple and Kaplan (2000) propose the following values for the PERS feature, where S and H are atomic symbols mnemonic for speaker and HEARER:

(66) Values for the PERS feature according to Dalrymple and Kaplan (2000):

{S,H}:	first person
{H}:	second person
{}:	third person

According to this analysis, the f-structure for a sentence such as *We yawned*, containing a first-person pronominal subject, is as follows, where the value {S,H} represents first person:

(67) *We yawned.*

$$\left[\begin{array}{ll} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{TENSE} & \text{PST} \\ \text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{INDEX} & \left[\begin{array}{ll} \text{PERS} & \{\text{S,H}\} \\ \text{NUM} & \text{PL} \end{array}\right] \end{array}\right] \end{array}\right]$$

The closed set description characterizing the value of the PERS attribute for the pronoun *we* is:

(68) *we* $(\uparrow \text{INDEX PERS}) = \{\text{S,H}\}$

This description differs from the open set description in (69), which is consistent with the presence of other members of the set; the constraint in (68) is not:

(69) *we* $\text{S} \in (\uparrow \text{INDEX PERS})$
$\text{H} \in (\uparrow \text{INDEX PERS})$

For example, an additional constraint $\text{O} \in (\uparrow \text{INDEX PERS})$ is compatible with the constraints in (69) but not with the constraint in (68).

Notably, there is a close relation between set-based representations for the value of a feature such as PERS and feature-based representations such as the one proposed by Otoguro (2015), illustrated in Chapter 2, Section 5.7.2, example (157), and repeated here:

(70) Values for the PERS feature according to Otoguro (2015):

First person: $\begin{bmatrix} \textsc{pers} & \begin{bmatrix} 1 & + \\ 2 & - \end{bmatrix} \end{bmatrix}$

Second person: $\begin{bmatrix} \textsc{pers} & \begin{bmatrix} 1 & - \\ 2 & + \end{bmatrix} \end{bmatrix}$

Third person: $\begin{bmatrix} \textsc{pers} & \begin{bmatrix} 1 & - \\ 2 & - \end{bmatrix} \end{bmatrix}$

As Sadler (2011) observes, any analysis that is expressed with closed set values is also expressible using a feature-based representation, though the reverse does not hold. In particular, it is possible to translate any set-based analysis of a complex feature value into a feature-based analysis by representing the presence of a member of the set with a positive (+) value for the corresponding attribute, and its absence by a negative (−) value.

(71)

	Set-based representation:	Feature-based representation:
First person	$\{\textsc{s},\textsc{h}\}$	$\begin{bmatrix} \textsc{pers} & \begin{bmatrix} \textsc{s} & + \\ \textsc{h} & + \end{bmatrix} \end{bmatrix}$
Second person	$\{\textsc{h}\}$	$\begin{bmatrix} \textsc{pers} & \begin{bmatrix} \textsc{s} & - \\ \textsc{h} & + \end{bmatrix} \end{bmatrix}$
Third person	$\{\}$	$\begin{bmatrix} \textsc{pers} & \begin{bmatrix} \textsc{s} & - \\ \textsc{h} & - \end{bmatrix} \end{bmatrix}$

In the feature-based representation, a value of + for a feature indicates that the feature is present in the set, while a value of − indicates that the feature is absent. Vincent and Börjars's (2007) more complex proposal for the representation of the value of PERS in (72) can also be restated in feature-based terms, as shown in (73):

(72) Values for the PERS feature according to Vincent and Börjars (2007):

{S,H}: first person inclusive
{S}: first person exclusive
{H}: second person
{}: third person

(73)

	Set-based representation:	Feature-based representation:
First person inclusive	$\{\textsc{s},\textsc{h}\}$	$\begin{bmatrix} \textsc{pers} & \begin{bmatrix} \textsc{s} & + \\ \textsc{h} & + \end{bmatrix} \end{bmatrix}$
First person exclusive	$\{\textsc{s}\}$	$\begin{bmatrix} \textsc{pers} & \begin{bmatrix} \textsc{s} & + \\ \textsc{h} & - \end{bmatrix} \end{bmatrix}$
Second person	$\{\textsc{h}\}$	$\begin{bmatrix} \textsc{pers} & \begin{bmatrix} \textsc{s} & - \\ \textsc{h} & + \end{bmatrix} \end{bmatrix}$
Third person	$\{\}$	$\begin{bmatrix} \textsc{pers} & \begin{bmatrix} \textsc{s} & - \\ \textsc{h} & - \end{bmatrix} \end{bmatrix}$

In fact, if we rename the S attribute as 1 and the H attribute as 2, it becomes clear that Otoguro's feature-based representation of complex PERS values in (70) is very close to the representation in (73).

The feature-based representation also differs from the set-based representation in straightforwardly allowing for underspecification. With a closed set specification, the members of the set must be explicitly enumerated; it is not possible for a set to be underdetermined as to whether or not it contains a particular member.[8] In contrast, in a feature-based representation a feature and its value can remain unspecified, and this can indicate a lack of information about whether the feature is present (with value +) or not (with value −).

4. REFERENCE TO SISTER NODES

In most work within LFG, only the up arrow ↑ and down arrow ↓ annotations are used in rules. This embodies a strong locality claim: only the functional relation between a daughter category and its mother can be stated, and not the relations among the f-structures of any other nodes in the tree. In some work, however, reference can also be made to the f-structures of sister nodes in a phrase structure rule. For example, Nordlinger (1998) presents an analysis of morphological composition in which crucial reference is made to the immediate left sister of a node and its f-structure.

In a phrase structure rule, the left sister of a node can be referred to by using the symbol $<\!*$, and its f-structure is represented as $\phi(<\!*)$. Similarly, the symbol $*\!>$ is used to refer to the immediately adjacent right sister.[9] This additional

[8] Kaplan (2017) points out that *subsumption* (Section 9.2) can be used in a set-based analysis to capture many of the effects of underspecification in a feature-based setting.

[9] Nordlinger (1998) uses the left arrow ← to refer to the f-structure of the left sister, and the right arrow → to refer to the f-structure of the right sister. We prefer the use of $\phi(<\!*)$ and $\phi(*\!>)$ for the f-structures corresponding to the left and right sisters of a node, since this avoids confusion with the use of the ← symbol in *off-path constraints*: see Section 6 of this chapter.

expressivity expands the domain of locality slightly, but not beyond the local mother-daughter configuration that is described by the c-structure rule.

5. LOCAL NAMES FOR F-STRUCTURES

In expressing constraints on f-structures, a *local name* can be used in a lexical entry or annotated phrase structure rule to refer to an f-structure (Kaplan and Maxwell 1996). The reference of a local name is restricted to the lexical item or rule element within which it occurs: this means that if the same local name is used in more than one daughter in a rule or more than one lexical item, it refers to different f-structures, not the same f-structure. A local name begins with the percent sign %.

A local name is particularly useful in expressions involving functional uncertainty: it makes it possible to name a particular f-structure that participates in the uncertainty and to place constraints on it. For example, the relative pronoun in Russian agrees in number and gender with the head noun of the noun phrase. Lipson (1981) discusses the following Russian example, in which the masculine singular relative pronoun *kotorogo* must be used with a masculine singular noun like *park*:

(74) *park, okolo kotorogo ja živu*
park.M.SG near which.M.SG I live
'the park near which I live'

As (74) shows, the relative pronoun can appear as a subconstituent of a displaced phrase such as *okolo kotorogo* 'near which'. The f-structure for this example is:[10]

[10] In Chapter 17, Section 1.2, we augment the f-structure for relative clauses with an attribute RELPRO, whose value is the f-structure of the relative pronoun within the clause-initial phrase. Although the presence of the RELPRO attribute would allow for a considerable simplification in the analysis of this example, we omit this attribute here in order to provide a clear illustration of how a local name is used.

(75) *park, okolo kotorogo ja živu*
park.M.SG near which.M.SG I live

$$\left[\begin{array}{ll} \text{PRED} & \text{'PARK'} \\ \text{INDEX} & \left[\begin{array}{ll}\text{NUM} & \text{SG}\\ \text{GEND} & \text{M}\end{array}\right] \\ \text{ADJ} & \left\{\left[\begin{array}{ll} \text{DIS} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{'NEAR}\langle\text{OBJ}\rangle\text{'} \\ \text{OBJ} & g\left[\begin{array}{ll}\text{PRED} & \text{'PRO'}\\ \text{PRONTYPE} & \text{REL}\\ \text{INDEX} & \left[\begin{array}{ll}\text{NUM}&\text{SG}\\ \text{GEND}&\text{M}\end{array}\right]\end{array}\right]\end{array}\right]\right\} \\ \text{PRED} & \text{'LIVE}\langle\text{SUBJ,OBL}_{\text{LOC}}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{'PRO'}\\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS}&1\\ \text{NUM}&\text{SG}\end{array}\right]\end{array}\right] \\ \text{OBL}_{\text{LOC}} & \end{array}\right]\right\}\end{array}\right]$$

In the analysis of (74), we would like to impose an agreement requirement that allows us to refer to the relative pronoun, which may be embedded at an arbitrary depth within the DIS phrase, and to constrain its NUM and GEND features. The following phrase structure rule accomplishes this:

(76)
$$\text{NP} \longrightarrow \begin{pmatrix}\text{N}\\ \uparrow=\downarrow\end{pmatrix} \begin{pmatrix}\text{CP}\\ \downarrow\in(\uparrow\ \text{ADJ})\\ (\downarrow\ \text{DIS} \in \text{GF}^*) = \%\text{RELPRO}\\ (\%\text{RELPRO PRONTYPE}) =_c \text{REL}\\ (\%\text{RELPRO INDEX NUM}) = (\uparrow\ \text{INDEX NUM})\\ (\%\text{RELPRO INDEX GEND}) = (\uparrow\ \text{INDEX GEND})\end{pmatrix}$$

This rule states that a Russian noun phrase consists of a head noun N and a CP relative clause. The first constraint, $\downarrow\in(\uparrow$ ADJ$)$, requires the CP's f-structure to be a member of the set of modifiers of the phrase (see Section 3.1 for more on specification of set membership). This is true of the f-structure in (75).

The relative clause CP contains a relative phrase, the phrase *okolo kotorogo* 'near which' in (74). The CP rule (not displayed here) ensures that the f-structure of this relative phrase is a member of the DIS set within the relative clause. According to the rule in (76), this DIS f-structure must contain a relative pronoun at some level of embedding GF* inside the DIS. This f-structure is referred to by a name local to this rule element as %RELPRO:

(77) $(\downarrow\ \text{DIS} \in \text{GF}^*) = \%\text{RELPRO}$

An f-structure name such as %RELPRO may be used either in a lexical item or in annotations on a particular category on the right-hand side of a phrase structure rule. The final three annotations in (76) place further constraints on the f-structure %RELPRO: it must have a PRONTYPE of REL (on PRONTYPE, see Chapter 2, Section 5.7.7), and its NUM and GEND must match the NUM and GEND of the mother NP:

(78) $(\%\text{RELPRO PRONTYPE}) =_c \text{REL}$
$(\%\text{RELPRO INDEX NUM}) = (\uparrow \text{INDEX NUM})$
$(\%\text{RELPRO INDEX GEND}) = (\uparrow \text{INDEX GEND})$

These constraints are satisfied if %RELPRO names the f-structure labeled *g* in (75). Using a local name like %RELPRO is essential in this instance: the use of a local name ensures that all of the constraints in (78) refer to the *same* f-structure. In particular, a set of expressions like the following are *not* equivalent to those in (78):

(79) $(\downarrow \text{DIS} \in \text{GF}^* \text{ PRONTYPE}) =_c \text{REL}$
$(\downarrow \text{DIS} \in \text{GF}^* \text{ INDEX NUM}) = (\uparrow \text{INDEX NUM})$
$(\downarrow \text{DIS} \in \text{GF}^* \text{ INDEX GEND}) = (\uparrow \text{INDEX GEND})$

The equations in (79) require some f-structure in the DIS set to contain an f-structure with a PRONTYPE of REL, a possibly different f-structure to have the same NUM as the full noun phrase, and a possibly different f-structure to have the same GEND as the full noun phrase; crucially, these constraints impose no requirement for the same f-structure to satisfy all of these constraints. It is the use of a local name that enforces the proper requirement.

6. OFF-PATH CONSTRAINTS

Off-path constraints (Jam 1990; Kaplan and Maxwell 1996; Crouch et al. 2008; Bresnan et al. 2016, 4.8) allow for constraints on features of the f-structures through which some long-distance path is defined. Let us consider the simple functional uncertainty expression in (80), which played a role in the annotated rule in (24). This equation states that the f-structure ↓ is the value of some grammatical function GF that may be embedded inside one or more COMPs:

(80) $(\uparrow \text{COMP}^* \text{ GF}) = \downarrow$

This equation involves a path consisting of a grammatical function GF embedded inside any number of COMP f-structures, but places no constraints on other features of the f-structures through which the path passes. Suppose, however, that we are interested not in all COMP f-structures, but only in those which contain some additional feature; in other words, we are concerned with a feature that is "off the path" traversed by the functional uncertainty expression COMP^* GF. Off-path constraints allow us to restrict attention to f-structures with the relevant features, as we now show.

6.1. The F-Structure →

Some English verbs allow extraction from their clausal complements, while others do not. For many (but not all) speakers, verbs of manner of speaking do not allow extraction (Erteschik 1973):

(81) *Who did Chris think/*whisper that David saw?*

Verbs allowing extraction are often called *bridge verbs*, while those disallowing extraction are called *nonbridge verbs*.

There is no reason to assume that the grammatical function of the clausal complements of these two verbs differs. Other than this difference between them, they behave the same syntactically; both bear the grammatical function COMP. A sentence with a bridge verb allowing extraction has an f-structure like the following:

(82) *Who did Chris think that David saw?*

$$\left[\begin{array}{ll}
\text{DIS} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\\ \text{PRONTYPE} & \text{WH}\end{array}\right]\right\}\\
\text{PRED} & \text{`THINK}\langle\text{SUBJ,COMP}\rangle\text{'}\\
\text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`CHRIS'}\end{array}\right]\\
\text{COMP} & \left[\begin{array}{ll}\text{COMPFORM} & \text{THAT}\\ \text{PRED} & \text{`SEE}\langle\text{SUBJ,OBJ}\rangle\text{'}\\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`DAVID'}\end{array}\right]\\ \text{OBJ} & \end{array}\right]
\end{array}\right]$$

We propose that a nonbridge verb specifies that its complement bears a feature that bridge verbs lack, which we will call LDD (for long-distance dependency), with value −. The path in a long-distance dependency may not pass through an f-structure with this feature:

(83) **Who did Chris whisper that David saw?*

$$\left[\begin{array}{ll}
\textsc{dis} & \left\{\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{pro}\text{'}\\ \textsc{prontype} & \textsc{wh}\end{array}\right]\right\}\\
\textsc{pred} & \text{`}\textsc{whisper}\langle\textsc{subj},\textsc{comp}\rangle\text{'}\\
\textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{`Chris'}\end{array}\right]\\
\textsc{comp} & \left[\begin{array}{ll}
\textsc{compform} & \textsc{that}\\
\textsc{pred} & \text{`}\textsc{see}\langle\textsc{subj},\textsc{obj}\rangle\text{'}\\
\boxed{\textsc{ldd} \quad -} & \\
\textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{`David'}\end{array}\right]\\
\textsc{obj} & \text{———}
\end{array}\right]
\end{array}\right]$$

In (83), the displaced question constituent is related to its within-clause function $\textsc{obj}$ by means of an equation such as the following on the phrase structure rule dominating the question phrase:

(84) $(\uparrow \textsc{comp}\ \textsc{obj}) = \downarrow$

The attributes $\textsc{comp}$ and $\textsc{obj}$ do not reflect the prohibition against extraction. Instead, this requirement must be stated "off the path" characterizing the dependency, as an additional condition on the f-structures along the path. In this case, we would like to express the following constraint:

(85) A $\textsc{comp}$ in the extraction path must not contain the pair $\langle \textsc{ldd}, - \rangle$.

We can use the expression $\rightarrow$ in an off-path constraint to express this requirement:

(86) $(\uparrow \underset{(\rightarrow\ \textsc{ldd}) \neq -}{\textsc{comp}}\ \textsc{obj}) = \downarrow$

In the expression in (87), the right arrow $\rightarrow$ stands for the value of the attribute $\textsc{comp}$:

(87) $\underset{(\rightarrow \textsc{ldd}) \neq -}{\textsc{comp}}$

In (88), the $\textsc{comp}$ attribute is boxed, and the f-structure denoted by $\rightarrow$ is labeled *s*:

(88) **Who did Chris whisper that David saw?*

$$\left[\begin{array}{ll} \text{DIS} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{‘PRO’}\\ \text{PRONTYPE} & \text{WH}\end{array}\right]\right\}\\ \text{PRED} & \text{‘WHISPER}\langle\text{SUBJ,COMP}\rangle\text{’}\\ \text{SUBJ} & \left[\text{PRED}\quad \text{‘CHRIS’}\right]\\ \boxed{\text{COMP}} & s\left[\begin{array}{ll}\text{COMPFORM} & \text{THAT}\\ \text{PRED} & \text{‘SEE}\langle\text{SUBJ,OBJ}\rangle\text{’}\\ \text{LDD} & -\\ \text{SUBJ} & \left[\text{PRED}\quad \text{‘DAVID’}\right]\\ \text{OBJ} & \end{array}\right]\end{array}\right]$$

The f-structure s contains the attribute LDD with value −. This is forbidden by the negative constraint $(\rightarrow \text{LDD}) \neq -$ in (86), accounting for the ungrammaticality of (88).

Slightly more generally, we can use an expression like the following to constrain long-distance dependencies in English:[11]

(89) $$(\uparrow \underset{(\rightarrow \text{LDD}) \neq -}{\text{COMP}^*}\ \text{GF}) = \downarrow$$

This expression indicates that any number of occurrences of the annotated COMP attribute $\underset{(\rightarrow \text{LDD}) \neq -}{\text{COMP}}$ displayed in (87) can occur in the long-distance path; in other words, the f-structure ↓ bears some grammatical function GF embedded inside any number of COMPs, as long as none of the COMP f-structures on the path contain the pair ⟨LDD, −⟩.

6.2. The F-Structure ←

We can also use the left arrow ← in off-path constraints to denote the f-structure which contains the annotated attribute and its value. To see the difference between the left arrow ← and the right arrow → in off-path constraints, consider the following expression, containing a generic attribute represented by ATTR and a generic value VALUE:

(90) $$(f\ \text{DIS}) = (f\ \underset{(\leftarrow \text{ATTR}) = \text{VALUE}}{\text{COMP}}\ \text{OBJ})$$

The occurrence of COMP which is annotated with the off-path constraint is boxed in (91), and the left arrow ← in the off-path constraint refers to the f-structure

[11] As in Section 1.2 of this chapter, this provisional characterization of constraints on question formation in English is incomplete; we provide a more complete treatment of the syntax and semantics of questions in Chapter 17.

in which the annotated attribute COMP appears, the one labeled f. The off-path constraint ($\leftarrow$ ATTR)=VALUE requires f to have an attribute ATTR with value VALUE:

(91) F-structure satisfying the constraint in (90):

$$f\left[\begin{array}{ll} \text{DIS} & \left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{PRONTYPE} & \text{WH} \end{array}\right] \\ \boxed{\text{ATTR}} & \boxed{\text{VALUE}} \\ \boxed{\text{COMP}} & g\left[\begin{array}{ll} \text{OBJ} & \ \end{array}\right] \end{array}\right]$$

If we replace the left arrow by the right arrow, the result is as in (92): it is not f which contains the attribute and value in question, but g, the value of the COMP attribute within f.

(92) a. $(f\ \text{DIS}) = (f \underset{(\rightarrow\ \text{ATTR}) = \text{VALUE}}{\text{COMP}}\ \text{OBJ})$

b. F-structure satisfying the constraint in (92a):

$$f\left[\begin{array}{ll} \text{DIS} & \left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{PRONTYPE} & \text{WH} \end{array}\right] \\ \boxed{\text{COMP}} & g\left[\begin{array}{ll} \boxed{\text{ATTR}} & \boxed{\text{VALUE}} \\ \text{OBJ} & \ \end{array}\right] \end{array}\right]$$

Przepiórkowski and Patejuk (2012) use the f-structure metavariable $\leftarrow$ in their analysis of case assignment in Polish. They provide the following summary of Polish casemarking requirements:

(93) a. **subjects** bearing structural case are in the nominative,

b. with the exception of numeral phrase subjects, headed by so-called governing numerals, which are in the accusative;

c. **objects** bearing structural case are in the accusative,

d. unless they are in the syntactic scope of sentential negation, in which case they are in the genitive.

These requirements hold for coordinate structures as well, with the result that the conjuncts in a coordinate structure may bear different cases. For example, a nominative noun phrase may be coordinated with an accusative numeral phrase, forming a coordinated subject in which each conjunct obeys the casemarking rules in (93):

(94) *[Janek i jego pięć córek] głosowali*
Janek.<u>NOM</u>.SG.M and his five.<u>ACC</u>.PL.F daughters.GEN.PL.F voted.3PL.M
przeciw ACTA.
against ACTA
'John and his five daughters voted against ACTA.'

Przepiórkowski and Patejuk propose two analyses for this pattern; the second, which they call the "conservative solution", involves off-path constraints and the features SC and ACM. The SC feature marks f-structures which are assigned structural case, and the ACM attribute with value REC marks f-structures for numerals governing a genitive noun. These features are involved in these implicational constraints on casemarking (see Chapter 5, Section 2.10 for definition and discussion of implicational constraints):[12]

(95) a. $\begin{bmatrix} (f\ \textsc{sc}) =_c + \\ (f\ \textsc{acm}) \neq \textsc{rec} \end{bmatrix} \Rightarrow (f\ \textsc{case}) = \textsc{nom}$

b. $\begin{bmatrix} (f\ \textsc{sc}) =_c + \\ (f\ \textsc{acm}) =_c \textsc{rec} \end{bmatrix} \Rightarrow (f\ \textsc{case}) = \textsc{acc}$

The constraint in (95a) specifies that subjects that are assigned structural case (these have the value + for the attribute SC) and are not numeral phrases (and so do not have the value REC for the feature ACM) are assigned NOMinative case. The constraint in (95b) specifies that subjects that are assigned structural case *and* are numeral phrases are assigned ACCusative case.

The issue, as Przepiórkowski and Patejuk observe, is that this constraint cannot be evaluated with respect to a coordinate structure as a whole, since, as shown in (94), some conjuncts in a coordinate phrase might be assigned nominative case according to constraint (95a), while others are assigned accusative case according to constraint (95b). Their solution involves passing the constraint into the coordinate structure via an off-path constraint on a distributive feature, so that the constraint can be satisfied independently for each conjunct.

According to Przepiórkowski and Patejuk's analysis, casemarking for Polish subjects is controlled by the following constraint, involving a conjunction of the implicational constraints in (95):

(96) $$(\uparrow\ \textsc{subj}\ \underset{\substack{\begin{bmatrix} (\leftarrow\ \textsc{sc}) =_c + \\ (\leftarrow\ \textsc{acm}) \neq \textsc{rec} \end{bmatrix} \Rightarrow (\leftarrow\ \textsc{case}) = \textsc{nom} \\ \begin{bmatrix} (\leftarrow\ \textsc{sc}) =_c + \\ (\leftarrow\ \textsc{acm}) =_c \textsc{rec} \end{bmatrix} \Rightarrow (\leftarrow\ \textsc{case}) = \textsc{acc}}}{\textsc{pred}}\ )$$

The entire expression is an existential constraint, requiring the subject to contain a PRED. Since SUBJ and PRED are distributive features, the off-path constraint applies to each conjunct separately: ← refers to an f-structure with the attribute PRED, which is either the single PRED of a noncoordinate SUBJ or each PRED in a coordinate subject. This entails that the existential constraint holds of each conjunct when the subject is a coordinate phrase, as required, and that the correct case (though possibly a different case) is assigned in each conjunct.

[12] Przepiórkowski and Patejuk's treatment of casemarking has been simplified for the purposes of exposition; see their paper and Chapter 2, Section 5.7.5 for more discussion and a formal analysis of the CASE attribute and its value.

Formally, we define the expressions ← and → as they are used in off-path constraints in the following way:

(97) Off-path constraints:

In an expression like $\underset{(\leftarrow\ s)}{a}$, ← refers to the f-structure of which *a* is an attribute.

In an expression like $\underset{(\rightarrow\ s)}{a}$, → refers to the value of the attribute *a*.

Using the f-structure variables ← and →, any kind of constraint can be written as an off-path constraint: defining equations, constraining equations, existential constraints, and other kinds of f-descriptions may be specified. We return to a discussion of off-path constraints and long-distance dependencies in Chapter 17.

7. TEMPLATES

The previous examples used functional descriptions associated with lexical entries and phrase structure rules in determining the f-structure for a particular annotated c-structure tree. The lexical entries and phrase structure rules of a language are associated with f-descriptions that characterize and constrain the f-structures (and, as we will see, other structures) of the utterances in which they appear. In formulating a theory of the structure of the lexicon and permissible annotations on phrase structure rules, it is important to be able to specify commonalities in f-descriptions associated with lexical entries and annotated phrase structure rules. *Templates* are used to express these commonalities.

7.1. Templates in Lexical Descriptions

Linguistic theories have adopted different views as to how commonalities in lexical entries should be captured. Early theories of the lexicon viewed it as "a kind of appendix to the grammar, whose function is to list what is unpredictable and irregular about the words of a language" (Kiparsky 1982). Such views were (and are) common among proponents of transformational approaches to syntax, since important linguistic generalizations are assumed to be best encoded transformationally, with the lexicon as a catch-all for linguistic facts that cannot be represented in general transformational terms.

With the advent of constraint-based, nontransformational theories like LFG, an alternative view of the lexicon emerged. Bresnan (1978) observed that many structural and behavioral generalizations over words and constructions are in fact best captured by *lexical redundancy rules*: for example, the active and passive forms of a transitive verb, or the base and dative-shifted variants of a ditransitive verb, are related by lexical rules rather than by syntactic transformations (see Bresnan et al. 2016, Chapter 3 for further discussion of this point). On this view, lexical information is no longer merely exceptional, idiosyncratic and therefore theoretically uninteresting. Instead, the lexicon and the rules relating lexical items become a prime locus of syntactic generalizations. The architecture of a richly structured lexicon and an articulated theory of relations among lexical forms is a hallmark of LFG, and the relations between lexical forms and the structure of the lexicon are an important focus of theoretical work.

One of the first proposals for explicitly representing generalizations that hold of classes of lexical items was made by Flickinger (1987), who represents the lexicon as a hierarchy of feature structures. Each node in the hierarchy represents some aspect of syntactic structure which is common to a number of lexical items: the word *yawns* belongs to the third-person singular present-tense class (like *devours*, *cooks*, and so on), the intransitive class (like *coughed*, *hiccup*, and so on), and to other classes as well. Classes of lexical items may be subclasses of other classes, or may partition other classes along several dimensions.

Work within LFG differs from this approach in that it does not appeal to a hierarchy of functional structures to encode linguistic generalizations. Instead, in keeping with the constraint-based view that pervades the theory of LFG, linguistic generalizations are expressed not in terms of relations between structures, but in terms of relations between *descriptions* of structures. An LFG functional description can be given a name, and this name can be used to stand for that functional description. These named descriptions are referred to as *templates* (Dalrymple et al. 2004b).

To illustrate the use of templates, we begin with a simple uninstantiated f-description associated with the verb *yawns*:

(98) *yawns* $(\uparrow \textsc{pred}) = \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'}$
$(\uparrow \textsc{vtype}) = \textsc{fin}$
$(\uparrow \textsc{tense}) = \textsc{prs}$
$(\uparrow \textsc{subj index pers}) = 3$
$(\uparrow \textsc{subj index num}) = \textsc{sg}$

This lexical entry contributes a PRED value for the verb, and also contains information about the form of the verb and its subject agreement requirements.

Some of the elements of this f-description are shared with other verbs: for example, all present tense verbs contribute the equations $(\uparrow \textsc{vtype})=\textsc{fin}$ and $(\uparrow \textsc{tense})=\textsc{prs}$, and all third person singular verbs contribute $(\uparrow \textsc{subj index pers})=3$ and $(\uparrow \textsc{subj index num})=\textsc{sg}$. We can define the templates PRESENT and 3SG to encode this information, associated with the appropriate pieces of the functional description:

(99) Template definitions for the templates PRESENT and 3SG:

a. $\textsc{present} \equiv (\uparrow \textsc{vtype}) = \textsc{fin}$
$(\uparrow \textsc{tense}) = \textsc{prs}$

b. $3\textsc{sg} \equiv (\uparrow \textsc{subj index pers}) = 3$
$(\uparrow \textsc{subj index num}) = \textsc{sg}$

The template name PRESENT names the functional description consisting of the two equations ($\uparrow$ VTYPE)=FIN and ($\uparrow$ TENSE)=PRS, and similarly for 3SG. In fact, however, we can further subdivide the functional description PRESENT in terms of the following template definitions:

(100) a. FINITE $\equiv$ ($\uparrow$ VTYPE) = FIN

b. PRESTENSE $\equiv$ ($\uparrow$ TENSE) = PRS

The template PRESENT can be defined in terms of these simpler templates:

(101) PRESENT $\equiv$ @PRESTENSE
@FINITE

When a template is referred to in a lexical entry or in the definition of another template, as in (101), it is preceded by an 'at' sign "@". These template definitions can be arranged in a template hierarchy to indicate interdependencies. Template hierarchies are usually represented as a graph, with the relation between nodes in the graph representing relations between templates. In the case at hand, we have the template hierarchy fragment in (102), showing that the template PRESENT is defined by reference to the template PRESTENSE and the template FINITE:

(102)

PRESENT
PRESTENSE FINITE

Note that this template hierarchy is unlike the type hierarchies of Head-Driven Phrase Structure Grammar (Pollard and Sag 1987, 1994; Ginzburg and Sag 2000) in that it encodes a relation between f-descriptions rather than a relation between structures. The template hierarchy in (102) indicates merely that the PRESENT template is defined by reference to the PRESTENSE and FINITE templates. Templates stand for f-descriptions, and f-descriptions can be conjoined, disjoined, or negated. Thus, the f-description contributed by the daughter nodes in this hierarchy may be related in a complex way to the f-description of the mother node, including via negation. This is not possible in a type hierarchy, where the hierarchy represents inheritance in a semilattice. Asudeh et al. (2008, 2013) provide further discussion of this point.

We can also subdivide the 3SG template as follows:

(103) a. 3PERSONSUBJ $\equiv$ ($\uparrow$ SUBJ INDEX PERS) = 3

b. SINGSUBJ $\equiv$ ($\uparrow$ SUBJ INDEX NUM) = SG

This gives the following definition of the template 3SG:

(104) 3SG $\equiv$ @3PERSONSUBJ
@SINGSUBJ

This information can also be represented as a template hierarchy:

(105)

```
        3SG
       /    \
3PersonSubj  SingSubj
```

Finally, we can define a template Pres3Sg for verb forms like *yawns*:

(106) Pres3Sg ≡ @present
@3sg

Our template hierarchy then becomes:

(107)

```
                    Pres3Sg
                  /         \
           present            3sg
          /       \          /     \
   prestense    finite  3PersonSubj  SingSubj
```

We can also provide a template that can be used with all intransitive verbs, by using a *parametrized template*. Parametrized templates take one or more arguments, written in parentheses after the template name. Here, we define a parametrized template which takes a single argument providing the pred specification:

(108) intransitive(_p) ≡ ($\uparrow$ pred) = '_p⟨subj⟩'

In the definition of the parametrized template, the argument _p is written with an underscore. When the template is used, it must be supplied with an argument, which is used as the pred specification for the lexical entry. For the verb *yawns*, the template is called in the following way:

(109) @intransitive(yawn)

Once we have expressed all of the relevant pieces of f-description in terms of templates, we have the following template definitions:

(110)

a.	intransitive(_p)	≡	($\uparrow$ pred) = '_p⟨subj⟩'
b.	Pres3Sg	≡	@present @3sg
c.	present	≡	@prestense @finite
d.	3sg	≡	@3PersonSubj @SingSubj
e.	prestense	≡	($\uparrow$ tense) = prs
f.	finite	≡	($\uparrow$ vtype) = fin
g.	3PersonSubj	≡	($\uparrow$ subj index pers) = 3
h.	SingSubj	≡	($\uparrow$ subj index num) = sg

Given these template definitions, the lexical entry for *yawns* is:

(111) *yawns* @INTRANSITIVE(YAWN)
@PRES3SG

The parametrized template INTRANSITIVE(_P) is shared by verbs like *sneezed*, *arrive*, and many others. The PRES3SG template is shared by verbs like *appears*, *goes*, *cooks*, and many others. The template PRESENT, used in defining the PRES3SG template, is also used by verbs like *bake*, *are*, and many others. The use of templates allows commonalities between lexical entries to be represented succinctly and for linguistic generalizations to be encoded in a theoretically motivated manner.

7.2. Templates in Phrase Structure Rules

Since templates simply stand for pieces of functional descriptions, it is also possible to use templates in annotations on phrase structure rules, to capture recurring generalizations in the specification of the relation between c-structure configurations and f-structures. There is no difference in the way templates are defined or called when they are used in phrase structure rules; the functional annotations in phrase structure rules can simply be replaced with a template.

For example, Bresnan (1982a, page 323) discusses control of depictive adjuncts, showing that the subject of a depictive adjunct within the VP can be controlled by the matrix subject, object, or secondary/thematically restricted object:[13]

(112) a. *The box arrived <u>unopened</u>.* (SUBJ control: the box is unopened)
SUBJ

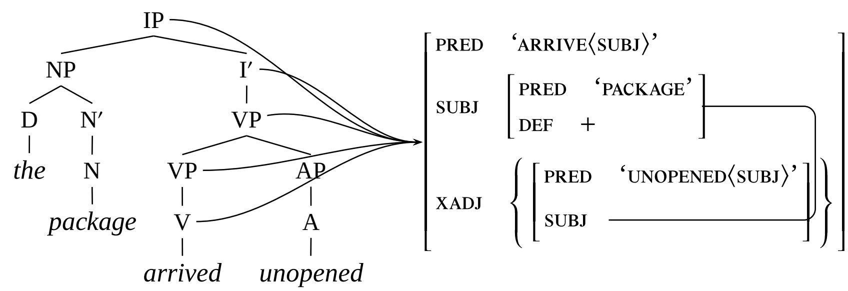
b. *John will serve the fish to you <u>raw</u>.* (OBJ control: the fish is raw)
OBJ

c. *I sent you the letter <u>sealed</u>.* (OBJ_θ control: the letter is sealed)
OBJ_θ

We assume that the adjective phrase in the VP-internal examples in (112) is adjoined at the VP level, and that the adjective phrase bears the open adjunct role XADJ. Under these assumptions, the c-structure and f-structure for (112a) are:

[13] For more on control, see Chapter 15.

(113) *The package arrived unopened.*



In this configuration, the subject of the XADJ *unopened* is required to be the same as the matrix SUBJ, OBJ, or OBJ_θ:

(114) VP ⟶ VP AP*
↑=↓ ↓∈ (↑ XADJ)
(↑ {SUBJ|OBJ|OBJ_θ}) = (↓ SUBJ)

For clause-initial adjuncts, the choice of the controller is more restricted; Bresnan (1982a, page 325) claims that clause-initial adjective phrase adjuncts permit control only by the matrix subject, and not by the object or other arguments:

(115) a. SUBJ control (Mary is sure of winning):

Sure of winning, Mary entered the competition yesterday.
SUBJ

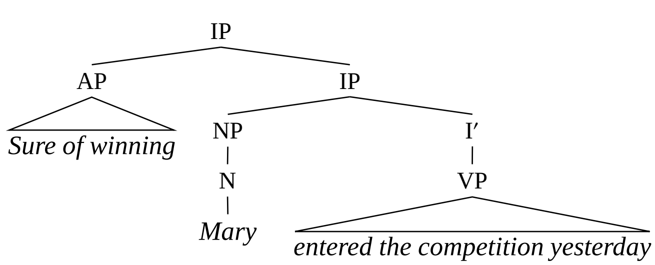
b. OBJ control not possible:

**Sure of winning, the competition excited Mary yesterday.*
OBJ

We assume that clause-initial adjuncts are adjoined to IP according to the rule in (116), with the matrix SUBJ specified as controller of the XADJ SUBJ. The tree for example (115a) is shown in (117).

(116) IP ⟶ AP* IP
↓∈ (↑ XADJ) ↑=↓
(↑ SUBJ) = (↓ SUBJ)

(117)



The annotations on AP in the rules in (114) and (116) are similar but not the same, and indeed, as we will see in Chapter 15, Section 8.1, Icelandic makes use of a phrase structure rule for depictive XADJ that is identical to (114). By using a template, we can capture the commonalities and differences in these rule annotations within and across languages.

We can define the parametrized template XADJ in the same way as for the parametrized INTRANSITIVE template in (108), with an argument for the grammatical function of the matrix controller:

(118) $\text{XADJ}(\_P) \equiv \downarrow\in(\uparrow \text{XADJ})$
$(\uparrow \ \_P) = (\downarrow \text{SUBJ})$

Given this definition, we can rewrite the rules in (114) and (116) in a way that illuminates the similarities and differences between them; the similarities are embodied in the call to the template XADJ, while the difference in control possibilities between the two constructions is reflected in the different arguments to each of the templates:

(119) a. $$\text{VP} \longrightarrow \begin{array}{cc} \text{VP} & \text{AP}^* \\ \uparrow=\downarrow & @\text{XADJ}(\{\text{SUBJ}|\text{OBJ}|\text{OBJ}_\theta\}) \end{array}$$

b. $$\text{IP} \longrightarrow \begin{array}{cc} \text{AP}^* & \text{IP} \\ @\text{XADJ}(\text{SUBJ}) & \uparrow=\downarrow \end{array}$$

Templates have been adopted in LFG-based work on *constructions*: Asudeh et al. (2008, 2013) provide an analysis of the *way*-construction (for example, *David dug his way out of prison*) which relies crucially on templates to express commonalities and differences in this construction and related constructions within and across languages. Other work relying on templates includes King et al. (2005) and Asudeh et al. (2014); Kaplan and Maxwell (1996) and Crouch et al. (2008) provide more discussion and exemplification.

8. C-STRUCTURE RULE MACROS

As we have seen, the use of *c-structure metacategories* allows us to express generalizations over natural classes of c-structure categories; as discussed in Chapter 5, Section 1.3, the metacategory XP can be defined as any full phrasal category with a lexical head, and this metacategory can be used in the statement of generalizations that hold across these categories:

(120) Definition of the metacategory XP:

XP ≡ {NP | PP | VP | AP | AdvP }

As shown in the previous section, we can express generalizations in the domain of functional descriptions by means of *templates*. We may also wish to encode more complex generalizations involving c-structure categories annotated with functional descriptions; we can do this by using a *c-structure rule macro*.

Consider, for example, the structure-function correlation proposed in Chapter 4, Section 2.2.1: complements of functional categories are f-structure coheads. The rules in (121) conform to this generalization, since both the head (I and C) and the complement (VP and IP) bear the annotation $\uparrow = \downarrow$:

(121)
$$\mathrm{I}' \longrightarrow \underset{\uparrow=\downarrow}{\mathrm{I}} \quad \underset{\uparrow=\downarrow}{\mathrm{VP}}$$
$$\mathrm{C}' \longrightarrow \underset{\uparrow=\downarrow}{\mathrm{C}} \quad \underset{\uparrow=\downarrow}{\mathrm{IP}}$$

We can encode the relevant generalization by means of the rule macro in (122), which provides a definition of coheadedness, and captures the commonalities between these two rules. The definition of a rule macro is similar to a template definition; in particular, rule macros can be parametrized, taking arguments. The macro definition in (122) takes two arguments, _H1 and _H2, representing the two cohead categories in the rule.

(122)
$$\textsc{cohead}(\_\textsc{h}1, \_\textsc{h}2) \equiv \underset{\uparrow=\downarrow}{\_\textsc{h}1} \quad \underset{\uparrow=\downarrow}{\_\textsc{h}2}$$

This macro definition is unlike a metacategory in that its categories are not plain (unannotated) categories, but are annotated with functional descriptions; it is unlike a template in that the definition includes one or more annotated c-structure categories, not only an f-description as in the definition of a template. Of course, metacategories and templates can be used in the definition of a rule macro, in the same way as they are normally used on the right-hand side of a phrase structure rule.

Using the macro in (122), we can restate the two rules in (121) as in (123), by using the COHEAD rule macro. The rules in (123) are exactly equivalent to the rules in (121):

(123)
$$\mathrm{I}' \longrightarrow @\textsc{cohead}(\mathrm{I}, \mathrm{VP})$$
$$\mathrm{C}' \longrightarrow @\textsc{cohead}(\mathrm{C}, \mathrm{IP})$$

As with templates, a call to a rule macro is preceded by an at sign "@". A c-structure rule macro can be used in place of any sequence of annotated categories in the grammar; like a template, it allows for the expression of generalizations in the grammar, commonalities across classes of annotated rules.

9. RELATIONS BETWEEN F-STRUCTURES

9.1. F-Command

F-command is a relation between f-structures analogous to the c-command relation defined on trees (Reinhart 1976). F-command was originally defined by Bresnan (1982a) in the following way:

(124) F-command:

> f f-commands g if and only if f does not contain g, and all f-structures that contain f also contain g.

In (125a) and (125b), the f-structure labeled f f-commands the f-structure labeled g. In (125a), but not in (125b), g also f-commands f:

(125) f f-commands g:

$$\text{a.}\ \begin{bmatrix} \textsc{subj} & f[\ ] \\ \textsc{obj} & g[\ ] \end{bmatrix} \qquad \text{b.}\ \begin{bmatrix} \textsc{subj} & f[\ ] \\ \textsc{comp} & \begin{bmatrix} \textsc{subj} & g[\ ] \end{bmatrix} \end{bmatrix}$$

The definition of f-command given in (124) is correct for cases like (125). However, as pointed out by Ron Kaplan (p.c.), this definition may not make the right predictions in cases in which two attributes share the same value. Consider the f-structure in (126), where the f-structure labeled f is the SUBJ as well as the XCOMP SUBJ:

(126)
$$\begin{bmatrix} \textsc{subj} & f[\ ] \\ \textsc{obj} & g[\ ] \\ \textsc{xcomp} & h\begin{bmatrix} \textsc{subj} & \end{bmatrix} \end{bmatrix}$$

The f-structure labeled f in (126) does not f-command the f-structure labeled g according to the definition in (124), because there is an f-structure (namely h) that contains f but does not contain g. For the f-command relation to hold between f and g, we can formulate a new definition of f-command using inside-out functional uncertainty (defined in Section 1.3 of this chapter):

(127) F-command, definition 2:

> f f-commands g if and only if $(f\ \textsc{gf}^*) \neq g$ (f does not contain g) and $((\textsc{gf}\ f)\ \textsc{gf}^+) = g$ (there is an f-structure $(\textsc{gf}\ f)$ which contains g at some level of embedding).

F-command is important in the definition of binding relations between pronouns and their antecedents: in many cases, the antecedent of a reflexive pronoun like *himself* must f-command that reflexive pronoun. The contrast in acceptability between (128a) and (128b) is due to the fact that in (128a), the antecedent f of the reflexive pronoun *himself* f-commands the f-structure g of the pronoun, while the f-command relation does not hold in (128b), because there is an f-structure m that contains f but not g:

(128) a. *David$_i$ saw himself$_i$.*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{see}\langle\textsc{subj,obj}\rangle\text{'} \\ \textsc{subj} & f\begin{bmatrix}\textsc{pred} & \text{`David'}\end{bmatrix} \\ \textsc{obj} & g\begin{bmatrix}\textsc{pred} & \text{`}\textsc{pro}\text{'} \\ \textsc{prontype} & \textsc{refl}\end{bmatrix}\end{bmatrix}$$

b. **David$_i$'s mother saw himself$_i$.*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{see}\langle\textsc{subj,obj}\rangle\text{'} \\ \textsc{subj} & m\begin{bmatrix}\textsc{pred} & \text{`}\textsc{mother}\text{'} \\ \textsc{poss} & f\begin{bmatrix}\textsc{pred} & \text{`David'}\end{bmatrix}\end{bmatrix} \\ \textsc{obj} & g\begin{bmatrix}\textsc{pred} & \text{`}\textsc{pro}\text{'} \\ \textsc{prontype} & \textsc{refl}\end{bmatrix}\end{bmatrix}$$

Chapter 14 provides a more in-depth discussion of constraints on anaphoric binding; there, we will see that the f-command condition for antecedents of reflexive pronouns follows as a corollary from the binding requirements for reflexives, along the lines of the definition in (127).

9.2. Subsumption

Subsumption is a relation that holds between two f-structures f and g if g is compatible with but perhaps has more structure than f. In other words, f subsumes g if f and g are the same, or if g is the same as f except that it contains some additional structure that does not appear in f. For example, the f-structure labeled f in (129) subsumes the f-structure labeled g:

(129) f subsumes g:

$$f\begin{bmatrix} \textsc{pred} & \text{`}\textsc{go}\langle\textsc{subj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix}\textsc{index} & \begin{bmatrix}\textsc{num} & \textsc{sg}\end{bmatrix}\end{bmatrix}\end{bmatrix} \qquad g\begin{bmatrix} \textsc{pred} & \text{`}\textsc{go}\langle\textsc{subj}\rangle\text{'} \\ \textsc{tense} & \textsc{fut} \\ \textsc{subj} & \begin{bmatrix}\textsc{pred} & \text{`}\textsc{pro}\text{'} \\ \textsc{index} & \begin{bmatrix}\textsc{pers} & 3 \\ \textsc{num} & \textsc{sg}\end{bmatrix}\end{bmatrix}\end{bmatrix}$$

The subsumption relation can be formally defined recursively, as follows:

(130) Subsumption:

An f-structure f subsumes an f-structure g ($f \sqsubseteq g$) if and only if:

$f = g$; or

f and g are sets, and for each member f_1 of f there is a member g_1 of g such that $f_1 \sqsubseteq g_1$; or

f and g are f-structures, and for each attribute-value pair $\langle a, v_1\rangle \in f$, there is a pair $\langle a, v_2\rangle \in g$ such that $v_1 \sqsubseteq v_2$.

9.3. Generalization

Intuitively, the *generalization* of two f-structures is the structure that they have in common. For example, in (131) the f-structure labeled f is the generalization of the f-structures g and h:

(131) f is the generalization of g and h:

$$f\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{go}\langle\textsc{subj}\rangle\text{'}\\ \textsc{subj} & \left[\textsc{def}\quad +\right]\end{array}\right]$$

$$g\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{go}\langle\textsc{subj}\rangle\text{'}\\ \textsc{tense} & \textsc{pst}\\ \textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{man}\text{'}\\ \textsc{def} & +\end{array}\right]\end{array}\right] \qquad h\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{go}\langle\textsc{subj}\rangle\text{'}\\ \textsc{tense} & \textsc{fut}\\ \textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{woman}\text{'}\\ \textsc{def} & +\end{array}\right]\\ \textsc{adj} & \left\{\left[\textsc{pred}\quad \text{`}\textsc{quickly}\text{'}\right]\right\}\end{array}\right]$$

Kaplan and Maxwell (1988b) use generalization in their analysis of coordination, proposing that the value of an attribute of a set is the generalization of the values of the attributes of the elements of the set. Their proposal predates the introduction of the distinction between distributive and nondistributive features, and is no longer generally accepted; we do not adopt it here.

Formally, the generalization $f_1 \sqcap f_2$ of two f-structures f_1 and f_2 is defined recursively as follows (see also Kaplan and Maxwell 1988b):

(132) Generalization:

An f-structure f is the generalization $f_1 \sqcap f_2$ of two f-structures f_1 and f_2 if and only if:

$f_1 = f_2 = f$; or

f_1 and f_2 are f-structures, and for each pair $\langle a, v_1\rangle \in f_1$, if there is a pair $\langle a, v_2\rangle \in f_2$, then $\langle a, v_1 \sqcap v_2\rangle \in f$; or

f_1 and f_2 are sets, and each member of f is the generalization of some member of f_1 and some member of f_2.

Unlike many previous definitions of generalization, (132) defines the generalization of two sets. This definition has an interesting consequence: the generalization of two sets may not be unique. For instance, consider the two sets in (133a) and (133b):

(133) a. $\left\{ \begin{bmatrix} \text{F1} & \text{v1} \\ \text{F2} & \text{v2} \end{bmatrix} \begin{bmatrix} \text{F3} & \text{v3} \\ \text{F4} & \text{v4} \end{bmatrix} \right\}$

b. $\left\{ \begin{bmatrix} \text{F1} & \text{v1} \\ \text{F3} & \text{v3} \end{bmatrix} \begin{bmatrix} \text{F2} & \text{v2} \\ \text{F4} & \text{v4} \end{bmatrix} \right\}$

According to the definition in (132), both of the following two sets constitute a generalization of the sets in (133):

(134) a. $\left\{ \begin{bmatrix} \text{F1} & \text{v1} \end{bmatrix} \begin{bmatrix} \text{F4} & \text{v4} \end{bmatrix} \right\}$

b. $\left\{ \begin{bmatrix} \text{F2} & \text{v2} \end{bmatrix} \begin{bmatrix} \text{F3} & \text{v3} \end{bmatrix} \right\}$

9.4. Restriction

The *restriction* of an f-structure with respect to an attribute can be intuitively defined as the f-structure that results from removing the attribute and its value (Kaplan and Wedekind 1993). The f-structure labeled $g|_{\text{TENSE}}$ in (135) is the restriction with respect to TENSE of the f-structure labeled g:

(135) $g|_{\text{TENSE}}$ is the restriction of g with respect to TENSE:

$$g \begin{bmatrix} \text{PRED} & \text{'GO}\langle\text{SUBJ}\rangle\text{'} \\ \text{TENSE} & \text{PST} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{'CHRIS'} \end{bmatrix} \end{bmatrix}$$

$$g|_{\text{TENSE}} \begin{bmatrix} \text{PRED} & \text{'GO}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{'CHRIS'} \end{bmatrix} \end{bmatrix}$$

More formally, Kaplan and Wedekind (1993) define the restriction of an f-structure f with respect to an attribute a as follows:[14]

[14]The definition in (136) allows us to characterize a set by describing its elements, according to the following format:

$$Y = \{X : ...\text{constraints on } X... \}$$

According to this schematic definition, Y is a set containing all elements X that satisfy the constraints on X that appear after the colon. For example, in the first part of the definition in (136), $f|_a$ is a set of all pairs $\langle s, v\rangle$ which are in f and which satisfy the constraint $s \neq a$. In other words, the first part of the expression, $\langle s, v\rangle \in f$, directs us to consider all of the attribute-value pairs $\langle s, v\rangle$ in the f-structure f, and the constraint $s \neq a$ restricts attention to those attribute-value pairs in f in which the attribute is not a.

(136) Restriction:

$f|_a \equiv \{\langle s, v\rangle \in f : s \neq a\}$

If a is a set-valued attribute, restriction removes the specified member of the set:

$$f|_{\langle av\rangle} \equiv \begin{cases} f|_a & \text{if } (f\ a) = \{v\} \\ f|_a \ \cup\ \{\langle a, (f\ a) - \{v\}\rangle\} & \text{otherwise} \end{cases}$$

Restriction is useful if an f-structure plays two syntactic roles, but with different syntactic requirements associated with each role. For example, let us assume that some f-structure f is shared as the SUBJ value of two different f-structures g_1 and g_2, but that f must take on a different CASE value in each structure. The equation in (137a) requires all of the attribute-value pairs of f other than CASE to be the same as the attribute-value pairs of g_1's SUBJ other than CASE, and the equation in (137b) imposes the same requirement for g_2:

(137) a. $f|_{\text{CASE}} = (g_1\ \text{SUBJ})|_{\text{CASE}}$

b. $f|_{\text{CASE}} = (g_2\ \text{SUBJ})|_{\text{CASE}}$

We can then specify different CASE values for the subjects of g_1 and g_2; the constraints in (138) are consistent with the requirements in (137):

(138) a. $(g_1\ \text{SUBJ CASE}) = \text{NOM}$

b. $(g_2\ \text{SUBJ CASE}) = \text{ACC}$

Kaplan and Wedekind (1993) use restriction in their analysis of the semantics of modification. We do not adopt their analysis in this book; we discuss the syntax and semantics of modification in Chapter 13. Asudeh (2011, 2012) uses the restriction operator in his analysis of syntactically inactive resumptive pronouns.

9.5. Priority Union

Kaplan (1987) first proposed the operation of *priority union*, defined in (139):[15]

(139) Priority union, definition 1:

An f-structure f/g is the priority union of f with g (or "f given g"), if f/g is the set of pairs $\langle a, v\rangle$ such that v is equal to the value of the attribute a in f if it exists, otherwise the value of a in g.

Intuitively, the priority union of two f-structures contains all the structure that each f-structure has, with the f-structure on the left of the slash "winning" if there is a conflict. For example, in (140) f/g is the priority union of f with g:

[15] The forward slash notation is used both for priority union of f-structures (f/g) and as the "Ignore" operator in c-structure rules (Section 1.1).

(140) f/g is the priority union of f with g:

$$f/g\begin{bmatrix} \textsc{subj} & s \\ \textsc{obj} & o1 \\ \textsc{comp} & c \\ \textsc{obj}_\theta & t \end{bmatrix}$$

$$f\begin{bmatrix} \textsc{subj} & s \\ \textsc{obj} & o1 \\ \textsc{comp} & c \end{bmatrix} \qquad g\begin{bmatrix} \textsc{subj} & s \\ \textsc{obj} & o2 \\ \textsc{obj}_\theta & t \end{bmatrix}$$

The priority union f/g has all the structure in f as well as all the structure in g that does not conflict with f.

Kaplan's original definition of priority union, given in (139), was intended as a proposal for the analysis of elliptical constructions. For example, we might assume the following incomplete f-structures for a coordinate sentence with gapping:

(141) *David saw Chris, and Matty Ken.*

$$\left\{ g\begin{bmatrix} \textsc{pred} & \text{`}\textsc{see}\langle\textsc{subj},\textsc{obj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`David'} \end{bmatrix} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{`Chris'} \end{bmatrix} \end{bmatrix} f\begin{bmatrix} \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`Matty'} \end{bmatrix} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{`Ken'} \end{bmatrix} \end{bmatrix} \right\}$$

An analysis of gapping that appeals to priority union might propose that the final f-structure f for the second conjunct *Matty Ken* is obtained by taking the priority union f/g: in effect, the f-structure for *Matty* would replace the f-structure for *David*, and similarly for the f-structures for *Chris* and *Ken*:

(142) f/g is the priority union of f with g:

$$f/g\begin{bmatrix} \textsc{pred} & \text{`}\textsc{see}\langle\textsc{subj},\textsc{obj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`Matty'} \end{bmatrix} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{`Ken'} \end{bmatrix} \end{bmatrix}$$

$$f\begin{bmatrix} \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`Matty'} \end{bmatrix} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{`Ken'} \end{bmatrix} \end{bmatrix} \qquad g\begin{bmatrix} \textsc{pred} & \text{`}\textsc{see}\langle\textsc{subj},\textsc{obj}\rangle\text{'} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`David'} \end{bmatrix} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{`Chris'} \end{bmatrix} \end{bmatrix}$$

Priority union produces for the second conjunct an f-structure like the one that would be associated with a sentence like *Matty saw Ken*.

Kaplan (1987) purposely formulated the definition of priority union to refer only to the top-level attributes of f and g; the definition given in (140) is not recursive. However, later work (for instance, Brun 1996b) assumes a recursive definition for priority union like the following:

(143) Priority union, definition 2:

An f-structure f/g is the priority union of f with g (or "f given g") if and only if:

f is atomic, and $f/g = f$; or,

f and g are sets, and $f/g = f \cup g$; or,

f is an f-structure, and:

if $\langle a, v_1 \rangle \in f$ and $\langle a, v_2 \rangle \in g$, then $\langle a, v_1/v_2 \rangle \in f/g$.
if $\langle a, v_1 \rangle \in f$ and there is no pair $\langle a, v_2 \rangle \in g$, then $\langle a, v_1 \rangle \in f/g$.
if $\langle a, v_2 \rangle \in g$ and there is no pair $\langle a, v_1 \rangle \in f$, then $\langle a, v_2 \rangle \in f/g$.

Future work will show which of these definitions is the most useful one.

10. C-STRUCTURE/F-STRUCTURE CONSTRAINTS

10.1. C-Structure Wellformedness: Nonbranching Dominance

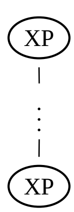
Constituent structure representations are governed by a constraint on valid derivations originally proposed by Kaplan and Bresnan (1982):

(144) Nonbranching Dominance Constraint, preliminary version:

A c-structure derivation is valid if and only if no category appears twice in a nonbranching dominance chain.

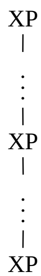
Intuitively, this requirement prevents a sentence from having an infinite number of c-structures by preventing a c-structure node from dominating another node with the same label in a nonbranching chain:

(145) Disallowed:



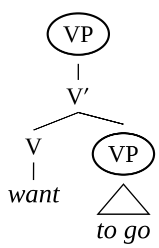
A tree like this one is not permitted: an XP cannot dominate another XP without also dominating some other material as well. If this were permitted, there could be a chain of XPs of unbounded length dominating any XP, giving rise to an infinite number of possible constituent structure trees for that XP:

(146) Disallowed:



Of course, a phrase may dominate a phrase of the same type if other material is present as well:

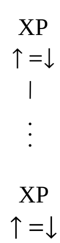
(147) Permitted:



This constraint is also discussed by Pereira and Warren (1983), who refer to the constraint as "off-line parsability"; this is because their formulation depends on the application of the nonbranching dominance constraint "off-line," after the parsing algorithm has been applied to derive a set of trees for a string. Johnson (1988) also provides a definition of off-line parsability that is very similar to the definition in (144).

In subsequent work, Kaplan and Maxwell (1996) revise the nonbranching dominance constraint to allow nonbranching dominance chains with nodes of the same category if the two nodes have different *functional annotations*. Under this view, the following dominance chain is ill-formed:

(148) Disallowed, revised nonbranching dominance constraint:



However, the following configuration is permitted:

(149) Permitted, revised nonbranching dominance constraint:

$$\begin{array}{c} \text{XP} \\ \uparrow = \downarrow \\ | \\ \vdots \\ \\ \text{XP} \\ (\uparrow \textsc{gf}) = \downarrow \end{array}$$

Under these assumptions, the final definition of the Nonbranching Dominance Constraint is:

(150) Nonbranching Dominance Constraint, final version:

A c-structure derivation is valid if and only if there are no categories with the same functional annotation appearing twice in a nonbranching dominance chain.

Kaplan and Bresnan (1982) show that the nonbranching dominance constraint is important in proving that the membership problem for lexical functional grammars is *decidable* — that it is always possible to determine whether a string is acceptable according to a given grammar:

(151) Decidability Theorem (Kaplan and Bresnan 1982, (181)):

For any lexical functional grammar *G* and for any string *s*, it is decidable whether *s* belongs to the language of *G*.

10.2. Category-Function Correlations

Certain lexical categories may tend to be associated only with certain grammatical functions or requirements. For example, Bresnan and Moshi (1990) propose that in general, only verbs and prepositions can subcategorize for the OBJ function (for similar claims, see Chomsky 1970, Bresnan 1976, Jackendoff 1977, and Bresnan and Kanerva 1989). However, exceptions to this tendency have often been noted: for instance, Maling (1983), Mittendorf and Sadler (2008), Al Sharifi and Sadler (2009), Vincent and Börjars (2010a), and Raza and Ahmed (2011) provide analyses of adjectives subcategorizing for objects; Lowe (2013, 2014c) discusses transitive nouns and adjectives in Avestan, and Lowe (2017b) presents a detailed analysis of transitive nouns and adjectives in Sanskrit.

There are also common correlations between phrase structure positions and functional annotations associated with those positions. For example, we have seen that in English the specifier of IP is associated with the grammatical function SUBJ. English also allows sentential subjects — that is, subjects with the phrase structure category CP; however, Bresnan (1994) presents evidence that the categories CP and PP cannot appear in the specifier of IP position, the canonical position for subjects (see also Bresnan et al. 2016): for instance, auxiliary inversion with a CP is not possible (Koster 1978). Of course, as Bresnan shows, this does not prevent phrases of those categories from bearing the SUBJ function, even though they do not appear in the position in which nominal subjects are generally found.

10.3. Inverse Correspondences and the CAT Predicate

In our discussion of subcategorization in Chapter 2, Section 3, we noted that LFG defines subcategorization requirements in functional terms: predicates subcategorize for a particular set of grammatical functions rather than for phrasal categories or configurations. In many instances, as shown by Maling (1983), what appears to be evidence for selection for a particular phrase structure category is often better explained in semantic terms. In some cases, however, constraints on syntactic category do seem to be at issue.

Some predicates are exceptional in that they impose a categorical requirement on their arguments, restricting the constituent structure category of the argument to be only a subset of the categories that may be associated with a particular grammatical function. As pointed out by Pollard and Sag (1994), *wax* is a relatively uncommon verb which requires an adjective complement, but is used mostly with a small set of adjectives like *poetical* and *lyrical*:

(152) a. *Kim waxed poetical.*

b. **Kim waxed a success.*

c. **Kim waxed sent more and more leaflets.*

d. **Kim waxed doing all the work.*

e. **Kim waxed to like anchovies.*

Sag et al. (1985) claim that the verb *become* requires either an AP or NP complement, and cannot appear with a PP or VP complement:

(153) a. *Pat has become a Republican.*

b. *Gerry became quite conservative.*

c. **Connie has become of the opinion that we should get out.*

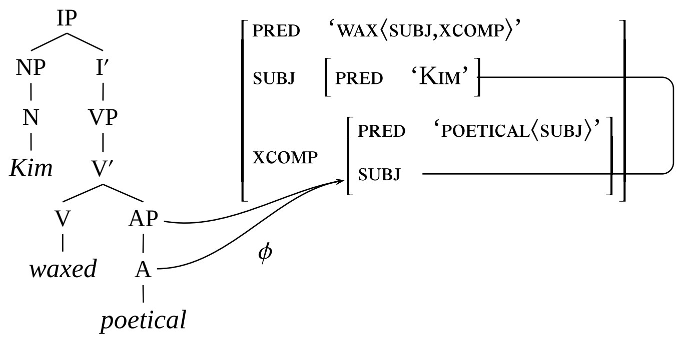
d. **Tracy became awarded a prize.*

e. **Chris will become talking to colleagues.*

In a theory where constituent structure information is available as readily as functional information in defining subcategorization requirements, the scarcity of such verbs is surprising. Our theory of subcategorization allows for these exceptional cases of categorical subcategorization, while reflecting the fact that in the normal case functional information is all that is relevant.

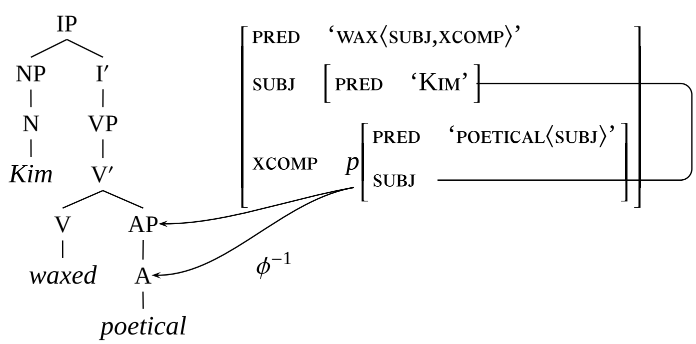
The c-structure/f-structure correspondence for an example like *Kim waxed poetical* is:

(154) *Kim waxed poetical.*



The ϕ function relating c-structure nodes to their f-structures is indicated by arrows. The *inverse* of this function, the ϕ^{-1} relation, is indicated by arrows pointing in the opposite direction in (155):

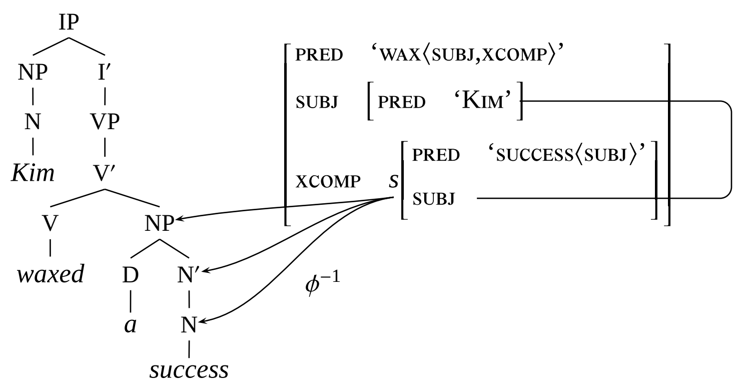
(155) *Kim waxed poetical.*



For each f-structure f, the *inverse correspondence* relation $\phi^{-1}(f)$ gives the c-structure nodes that are associated with that f-structure; the relation between f-structures and their corresponding c-structure nodes is therefore not a function, because more than one c-structure node can correspond to a single f-structure. For the f-structure labeled p in (155), $\phi^{-1}(p)$ yields the nodes labeled AP and A.

Example (156) gives the c-structure and f-structure for the ill-formed sentence *Kim waxed a success*:

(156) **Kim waxed a success.*



For this example, the f-structure labeled s is associated via the inverse ϕ correspondence with three nodes, those labeled NP, N′, and N.

We can now state the categorical requirement imposed on the complement of the verb *wax* by using the predicate CAT (Kaplan and Maxwell 1996; Crouch et al. 2008), defined in terms of the inverse ϕ correspondence and the λ function from c-structure nodes to category labels (see Chapter 5, Section 1.2). The CAT predicate allows the statement of constraints on the category of the c-structure nodes corresponding to an f-structure. Formally, CAT is defined in the following way:[16,17]

(157) Definition of CAT:

CAT(f, C) if and only if $\exists n \in \phi^{-1}(f) : \lambda(n) \in C$.

CAT(f, C) is true if and only if there is some node n that corresponds to f via the inverse ϕ correspondence (ϕ^{-1}) whose label (λ) is in the set of categories C.

According to this definition, the relation CAT(f, C) holds between an f-structure f and a set of category labels C if the label of one of the nodes n in the set of nodes corresponding to f is a member of C. In the wellformed example (155), the following is true, since one of the nodes corresponding to f has the label AP:

(158) CAT(f, {AP})

Thus, we posit the following category requirement, lexically associated with the verb *wax*:

[16] This definition of CAT conforms to the definition given by Kaplan and Maxwell (1996) and Crouch et al. (2008), but differs from the definition in Dalrymple (2001).

[17] The symbol $\exists$ is an *existential quantifier*: an expression like $\exists n$.... asserts that some individual n exists that meets the description represented by the following formula. The first part of the expression, $\exists n \in \phi^{-1}(f)$, directs us to consider the nodes n which are related to f via the inverse ϕ correspondence, and $\lambda(n) \in C$ requires the category label $\lambda(n)$ of at least one of those nodes to be in the set of node labels C.

(159) *wax*: CAT((↑ XCOMP), {AP})

This requirement ensures that one of the c-structure nodes associated with the XCOMP has the category AP, as required.

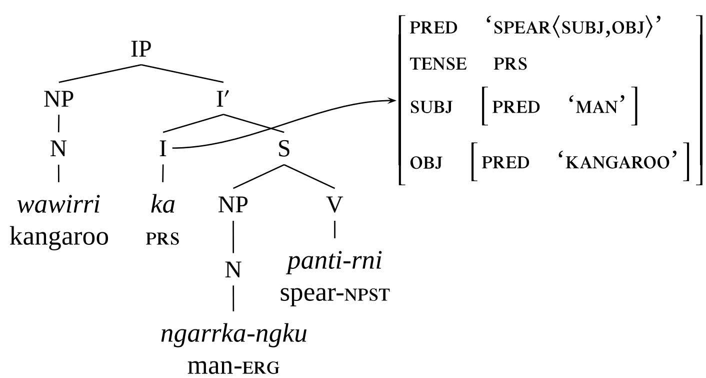
10.4. Empty Node Rules

In her analysis of Warlpiri, Simpson (1991) discusses gaps in morphological paradigms, showing that the Warlpiri AUX does not appear in what she calls the "null perfect aspect":

(160) *Japanangka-rlu ∅ pantu-rnu marlu*
Japanangka-ERG PRF spear-PST kangaroo
'Japanangka speared the kangaroo.'

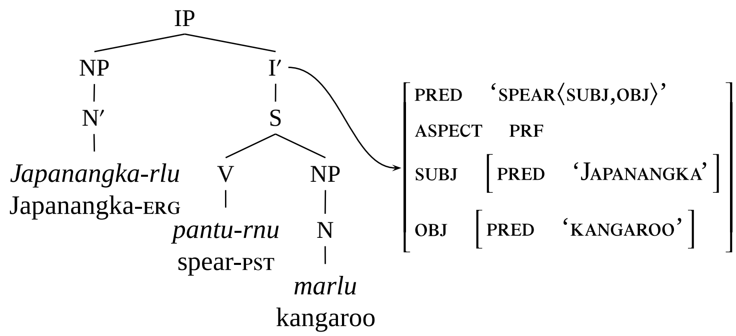
According to the generalization that Simpson formulates, there are two possibilities for phrasal expansion of I′. In (161), with a "non-null" auxiliary, the first daughter of I′ is I:

(161) *wawirri ka ngarrka-ngku panti-rni*
kangaroo PRS man-ERG spear-NPST
'The man is spearing the kangaroo.'



In (162), no auxiliary appears, and the sentence is interpreted as having perfect aspect:

(162) *Japanangka-rlu* ∅ *pantu-rnu marlu*
Japanangka-ERG PRF spear-PST kangaroo
'Japanangka speared the kangaroo.'



In Warlpiri, then, the absence of an auxiliary requires the presence of an ASPECT attribute in the f-structure with the value PRF.

The rule in (163) expresses the possibilities Simpson outlines for the phrase structure expansion of the category I′ in Warlpiri:

(163) $$\mathrm{I}' \longrightarrow \left\{ \begin{array}{c} \mathrm{I} \\ \uparrow = \downarrow \end{array} \;\middle|\; \begin{array}{c} \epsilon \\ (\uparrow \textsc{aspect}) = \textsc{prf} \end{array} \right\} \begin{array}{c} \mathrm{S} \\ \uparrow = \downarrow \end{array}$$

In this rule, the symbol ϵ corresponds to the empty string and represents the absence of a phrase structure constituent. Importantly, the rule does not license the presence of an empty category or node in the c-structure tree. Instead, it simply constitutes an instruction to introduce some functional constraints in the absence of some overt word or phrase. No empty node is introduced into the tree, as (162) shows.

The rule in (163) contains a disjunction: in one case, an auxiliary appears in I, while in the other case no auxiliary appears, and the sentence is interpreted as having perfect aspect. In fact, the rule in (163) is exactly equivalent to:

(164) $$\mathrm{I}' \longrightarrow \left\{ \begin{array}{c} \mathrm{I} \\ \uparrow = \downarrow \end{array} \begin{array}{c} \mathrm{S} \\ \uparrow = \downarrow \end{array} \;\middle|\; \begin{array}{c} \mathrm{S} \\ \uparrow = \downarrow \\ (\uparrow \textsc{aspect}) = \textsc{prf} \end{array} \right\}$$

However, although the rule in (164) also represents the two possible phrase structure expansions of I′, it is more cumbersome and fails to express Simpson's generalization. By using the symbol ϵ, the generalization can be expressed concisely.

11. LINEAR RELATIONS AND THE STRING

11.1. String Wellformedness Conditions

Recall from Chapter 3, Section 5 that, as proposed by Kaplan (1987, 1995), constituent structure is projected via the function π from a string of words which constitute the terminal nodes of the c-structure tree. Strings are governed by string wellformedness conditions, or *string constraints* (Lowe and Mycock 2014), which define the valid strings for a language; they are to strings what phrase-structure rules are to c-structure. Only strings which conform to all of the relevant string constraints for a language can participate in full, wellformed grammatical analyses. Here, we briefly discuss such string wellformedness conditions and how they are formally expressed. We will examine the string and its two aspects, the *s-string* or string of syntactic units relevant for c-structure, and the *p-string*, the string of prosodic units relevant for prosodic structure, in detail in Chapter 11.

The string constraints that are relevant in a language are formally stated as a *regular expression* (see Section 1 of this chapter) encoding universal and language-specific conditions which all wellformed strings in the language must obey. Since more than one type of string constraint may be relevant in a language, the regular expression encoding the combination of all of the string constraints is likely to be fairly complex. It is, then, preferable to define it by reference to a set of basic conditions, each of which reflects some particular generalization about string wellformedness. Taking advantage of the fact that regular languages are closed under the operations of union, intersection, and complementation, we can make use of these operations to combine a set of basic conditions into a single regular expression which imposes each of the separate conditions.

The most useful operation for combining basic constraints is *intersection*, since the intersection of two regular languages contains the strings that the two regular languages have in common: in other words, the use of intersection amounts to imposing both of the constraints simultaneously. For example, we can impose two basic conditions encoded by two regular expressions $R1$ and $R2$ by intersection (&); the resulting regular expression $R1\&R2$ picks out the set of strings that obey the conditions imposed by both $R1$ and $R2$.[18] We provide examples of basic string constraints and their combinations in Part II of the book.

We define separate, basic string constraints as components of the string wellformedness requirements for a language: for instance, in Chapter 11, Section 6 we impose a condition on the s-string requiring each component of a focused string to be marked with the label 'DFFoc'. Strings that do not obey this requirement are not wellformed, and are rejected. Additional universal and language-specific wellformedness conditions may also be imposed by combining them with the other string constraints for a language; the complete collection of wellformedness conditions are expressed as separate, basic regular expressions, and

[18] As discussed in Section 1 of this chapter, the symbol & that is generally used for the intersection of two regular languages is different from the symbol $\cap$ used for the intersection of two sets.

the string wellformedness conditions for a language are defined by a combination of regular expressions encoding each of the basic conditions.

11.2. String Precedence

Linear order relations in the string may also play a role in defining syntactic constraints. For example, Asudeh (2009) provides an analysis of the Complementizer-Adjacent Extraction (CAE) constraint on question formation in modern English, originally observed by Perlmutter (1971), which disallows extraction of a subject in most cases if a complementizer is present (see Chapter 17, Section 1.3.4):

(165) *Who do you think (*that) ___ saw Kim?*

Nonsubject constituent question formation is possible whether or not a complementizer is present:

(166) *Who do you think (that) Kim saw ___?*

Extraction of a subject is also possible if the complementizer is followed by an adverb (Bresnan 1977); this is sometimes referred to as the Adverb Effect:

(167) *Who did you say that, just a minute ago, ___ sneezed?*

The pattern is reversed for relative clauses, where the complementizer is required in subject relativization in most varieties of contemporary English (Bresnan 1977):

(168) a. *This is the person [that ___ sneezed].*
b. **This is the person [∅ sneezed].*

Asudeh (2009) discusses these and other patterns involving subject and nonsubject extraction in question formation and relative clause formation in detail; for the full account, see Asudeh (2009). He proposes the following constraint, lexically associated with the complementizer:

(169) CAE Constraint, Asudeh (2009), informal version:

It is not the case that the string element that immediately follows the complementizer maps to an f-structure that contains a subject that is both phonologically realized and is the head of an unbounded dependency.

In order to provide an explicit formal treatment of this constraint, Asudeh defines a function REALIZED, which is true of an f-structure if it corresponds to one or more c-structure nodes. This function is defined in terms of the inverse relation ϕ^{-1} from f-structures to c-structure nodes, discussed in Section 10.3 of this chapter, and holds of an f-structure f if there is some c-structure node that corresponds to f:

(170) REALIZED(f) holds if and only if $\phi^{-1}(f) \neq \emptyset$.

Asudeh also defines a function N (for *N*ext), which relates a word in a string to the next word in the string. N is defined for all words in the string except for the last word, since there is no word immediately following the final word in the string. The inverse of this function, N^{-1}, relates a word to the previous word in the string.

(171) $N(word1) = word2$ if and only if *word2* immediately follows *word1* in the string.

$N^{-1}(word2) = word1$ if and only if *word2* immediately precedes *word1* in the string.

Given this definition of N for the next word in a sentence and the π function from words to terminal nodes in the c-structure, we can use the familiar ϕ function to refer to the f-structure corresponding to the c-structure node dominating the next word in the string. We follow Asudeh in using the expression $\succ$ for this f-structure.[19]

(172) For a word w in the string, $\succ$ is the f-structure corresponding to the preterminal node dominating the next word in the string:

$$\succ \quad \equiv \quad \phi(\pi(N(w)))$$

We can define the expression $\prec$ in a similar way, to refer to the f-structure corresponding to the c-structure node dominating the *preceding* word in the string. The $\prec$ expression is not used in Asudeh's analysis of the CAE constraint.

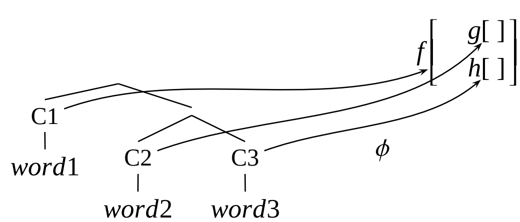
(173) For a word w in the string, $\prec$ is the f-structure corresponding to the preterminal node dominating the previous word in the string:

$$\prec \quad \equiv \quad \phi(\pi(N^{-1}(w)))$$

Note that $\succ$ is not defined for the last word in the string (which has no word following it), and $\prec$ is not defined for the first word in the string (which has no word preceding it).

Either $\succ$ or $\prec$ may appear in a lexical entry. Since these expressions are defined over words in a string, they may not appear in a c-structure annotation, since their definitions rely on the relation N which holds between words in the string rather than the c-structure precedence relation discussed in Section 11.3. Consider the following configuration:

(174)



[19] Our definition differs slightly from the one provided by Asudeh (2009) because we assume that words in the string are related to nodes in the c-structure via the function π; see Chapter 3, Section 5 and Chapter 11, Section 4.1 for more discussion of our architectural assumptions.

In (174), the terminal string is *word1 word2 word3*. According to the definition of the N function, the following statements define the Next function for this string:

(175) $N(word1) = word2$
$N(word2) = word3$

The π function from words of the string to preterminal nodes is:

(176) $\pi(word1)$ is the node labeled C1
$\pi(word2)$ is the node labeled C2
$\pi(word3)$ is the node labeled C3

We can restate the second and third line of (176), using the N function to refer to the next word, as:

(177) $\pi(N(word1))$ is the node labeled C2
$\pi(N(word2))$ is the node labeled C3

Finally, we can refer to the f-structures corresponding to each of these nodes:

(178) $\phi(\pi(N(word1))) = g$
$\phi(\pi(N(word2))) = h$

Thus, for *word1*, $\succ$ would refer to g, and for *word2*, $\succ$ would refer to h.

Still following the analysis of Asudeh (2009), we can now state the CAE constraint in formal terms:

(179) CAE Constraint, Asudeh (2009), formal version:

$\neg[\textsc{realized}(\succ\ \textsc{subj}) \wedge (\textsc{dis} \in (\succ\ \textsc{subj}))]$

This constraint appears in the lexical entry of the complementizer *that*, and rules out the possibility that the f-structure of the word following *that* has a subject ($\succ$ SUBJ) that (i) has a c-structure realization (REALIZED($\succ$ SUBJ)) and (ii) is a member of the DIS set, establishing a long-distance dependency (DIS $\in$ ($\succ$ SUBJ)).[20] This constraint is satisfied in one of three circumstances. First, if the f-structure of the word following the complementizer *that* has no SUBJ, then ($\succ$ SUBJ) does not exist and the CAE Constraint is satisfied. Second, if the f-structure of the following word has a subject, but it is not realized, the statement REALIZED($\succ$ SUBJ) is false and the CAE Constraint is satisfied (this is the case for relative clauses with no relative pronoun, such as *This is the person that/$*\emptyset$ sneezed*). Third, if the f-structure of the following word has a subject that is realized but does not appear in the DIS set, the f-structure (DIS $\in$ ($\succ$ SUBJ)) does not exist, and the CAE Constraint is satisfied; this covers the case of nonsubject relatives such as *Who do you think that Kim saw?* as well as declarative complements with no DIS, such as *I think that Kim saw David*). The analysis makes crucial use of the N relation, defined over elements of the string.

[20] The expression (DIS $\in$ ($\succ$ SUBJ)) is an existential constraint requiring that the f-structure ($\succ$ SUBJ) is a member ($\in$) of a DIS set. In this expression, the set-membership symbol $\in$ is used as an attribute selecting a member of the DIS set (Section 3.1).

11.3. C-Structure Precedence

The notion of c-precedence for c-structure nodes is the intuitively familiar notion of linear precedence, definable in the following terms (see also Partee et al. 1993, section 16.3.2):

(180) A c-structure node n_1 c-precedes a node n_2 if and only if n_1 does not dominate n_2, n_2 does not dominate n_1, and all nodes that n_1 dominates precede all nodes that n_2 dominates.

11.4. Functional Precedence

Functional precedence is a relation between two f-structures based on the c-structure precedence relation holding between the c-structure nodes corresponding to the two f-structures. Although it is based on the c-structural relation of precedence, it is different in interesting ways; differences between the two relations show up most clearly when an f-structure is related to discontinuous c-structure elements, and when an f-structure does not correspond to any c-structure nodes.

Kameyama (1989) presents an analysis of Japanese pronominals that accounts for the distribution of overt pronominals as well as "null" pronouns, pronouns that appear at f-structure but not c-structure (see also Kameyama 1985). As Kameyama shows, overt pronouns must follow their antecedents. In the unacceptable example in (181a) the pronoun *kare* precedes its antecedent *Taroo*, while (181b), in which *Taroo* precedes the pronoun, is acceptable:

(181) a. ??*kare-no imooto-o Taroo-ga sewasiteiru (koto...)*
his-GEN sister-ACC Taro-NOM be.taking.care.of that
'...(that) Taro$_i$ was taking care of his$_i$ sister'

b. *Taroo-ga kare-no imooto-o sewasiteiru (koto...)*
Taro-NOM his-GEN sister-ACC be.taking.care.of that

In contrast, there are no restrictions on the relation between the null pronominal and the definite antecedent. Whether *imooto* 'sister' precedes or follows *Taroo*, we may interpret *imooto* with a null possessive pronoun anteceded by *Taroo*:

(182) a. *imooto-o Taroo-ga sewasiteiru (koto...)*
[∅'s] sister-ACC Taro-NOM be.taking.care.of that
'...(that) Taro$_i$ was taking care of his$_i$ sister'

b. *Taroo-ga imooto-o sewasiteiru (koto...)*
Taro-NOM [∅'s] sister-ACC be.taking.care.of that

Simplifying Kameyama's analysis somewhat, these and other examples show that the antecedent of an overt pronoun must precede the pronoun, while this constraint does not hold for null pronouns. The facts about pronominal binding in Japanese can be given a uniform explanation in terms of f-precedence:

(183) The antecedent of a pronoun must *f-precede* the pronoun.

This generalization about anaphoric binding in Japanese holds under the following definition of f-precedence (Kaplan and Zaenen 1989b; Kameyama 1989):

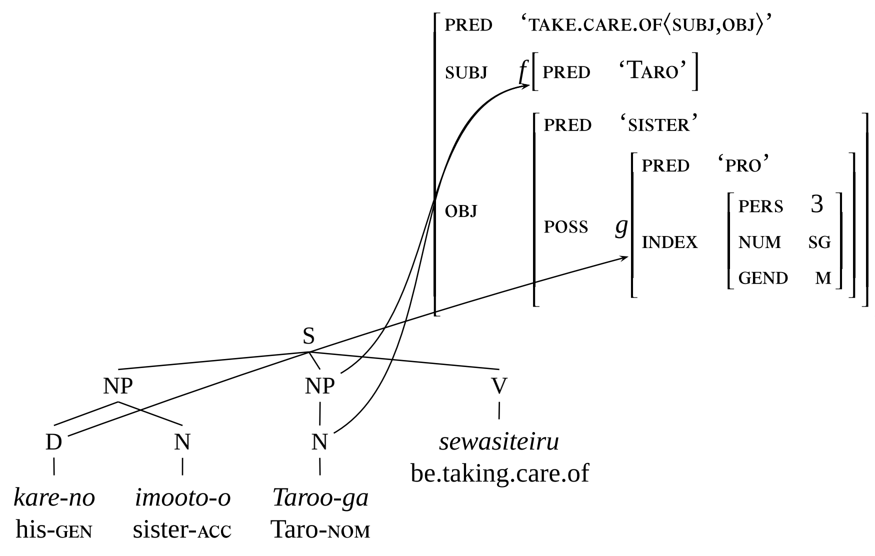
(184) F-precedence, definition 1 (Kaplan and Zaenen 1989b):

f *f-precedes* g ($f <_f g$) if and only if for all $n_1 \in \phi^{-1}(f)$ and for all $n_2 \in \phi^{-1}(g)$, n_1 c-precedes n_2.

This definition appeals to the *inverse relation* ϕ^{-1}, defined in Section 10.3 of this chapter, which associates f-structures with the c-structure nodes they correspond to. It also relies on the definition of c-precedence given in (180) in Section 11.3 above.

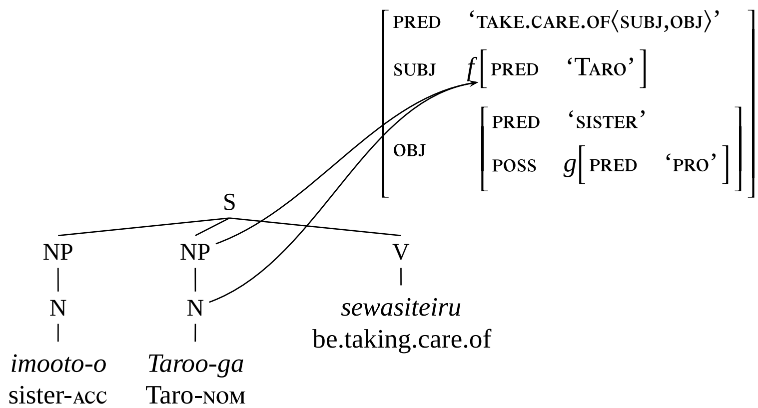
This definition of f-precedence states that an f-structure f f-precedes an f-structure g if and only if all of the nodes corresponding to f c-precede all of the nodes corresponding to g in the c-structure. In the unacceptable example in (185), the f-structure g of the possessive pronoun *kare-no* f-precedes the f-structure f of the antecedent *Taroo*, since all of the nodes corresponding to g (the D node) precede the nodes corresponding to f (the NP and N nodes):

(185) ??*kare-no imooto-o Taroo-ga sewasiteiru (koto...)*
his-GEN sister-ACC Taro-NOM be.taking.care.of that
'...(that) Taro$_i$ was taking care of his$_i$ sister'



What is the situation with null pronominals, pronouns that do not appear at c-structure? Consider the c-structure and f-structure for (186), which is like (185) except for having a null pronoun (realized only at f-structure) in place of the overt possessive pronoun *kare-no*:

(186) *imooto-o* *Taroo-ga sewasiteiru* *(koto. . .)*
[∅'s] sister-ACC Taro-NOM be.taking.care.of that
'. . . (that) Taro$_i$ was taking care of ∅$_i$ sister'



Crucially, the f-structure of the null pronoun does not correspond to any c-structure node. According to the definition of f-precedence given in (184), null elements vacuously f-precede and are f-preceded by all other elements in the sentence; in particular, null pronouns vacuously satisfy the constraint of being preceded by their antecedents. Thus, a uniform statement of antecedent requirements for Japanese null and overt pronominals, together with the definition of f-precedence given in (184), makes the correct predictions.

The definition of f-precedence in (184) is the one originally proposed by Bresnan (1984) and used by Kameyama (1989) and by Kaplan and Zaenen (1989b) in their analysis of word order in Dutch and German. A different definition is proposed by Bresnan et al. (2016) in their analysis of weak crossover:

(187) F-precedence, definition 2 (Bresnan et al. 2016, page 213):

f f-precedes g if and only if the rightmost node in $\phi^{-1}(f)$ precedes the rightmost node in $\phi^{-1}(g)$.

This definition gives a different result for f-structures that do not correspond to any c-structure nodes, since such f-structures do not have a corresponding rightmost node. Under definition 2 in (187), f-structures that do not correspond to any c-structure node do not f-precede any other f-structure, and they are not f-preceded by any other f-structure.

With the formal tools that have now been introduced, we are ready to begin a full-scale excursion into new linguistic realms. In the following chapters, we will explore other levels of nonsyntactic linguistic structure and how they are represented.

Part II

Beyond Syntactic Structures

Thus far, our discussion has centered on two linguistic structures: the constituent structure (c-structure) represents phrasal groupings and precedence relations, and the functional structure (f-structure) represents more abstract functional syntactic predicate-argument relations. In Part II, we explore the relation between these syntactic structures and other linguistic levels and structures. Chapter 7 (Beyond C-Structure and F-Structure: Linguistic Representations and Relations) provides an overview of the LFG projection architecture, the content and representation of nonsyntactic levels of linguistic structure, and their interfaces.

Each of the subsequent chapters in Part II describes a different module of linguistic structure. The chapters in Part II are fairly self-contained, with a few exceptions:

- Chapter 8 (Meaning and Semantic Composition) introduces the LFG theory of semantic representation, semantic composition, and the syntax-semantics interface. This is a central chapter in Part II, and understanding the semantic analyses in Part III and many of the chapters in Part II requires familiarity with the material covered in this chapter.

- Chapter 9 (Argument Structure and Mapping Theory) discusses argument structure and LFG's mapping theory. This chapter is self-contained, and can be skipped by readers who are not concerned with the content and representation of argument structure and argument linking.

- Chapter 10 (Information Structure) presents the LFG view of information structure, the structuring or "packaging" of the information conveyed by an utterance in a particular context. Familiarity with the material in Chapter 8 (Meaning and Semantic Composition) is necessary for a full understanding of this chapter. The material covered in Chapter 10 is an important basis for our analysis of prosodic structure in Chapter 11 (Prosodic Structure) and in our discussion of questions in Part III, Chapter 17 (Long-Distance Dependencies), but will not play a role elsewhere in Part II and Part III.

- Chapter 11 (Prosodic Structure) discusses prosodic structure and its relation to syntax, semantics, and information structure. A full understanding of all aspects of our formal analysis of prosodic structure relies on the material covered in Chapter 8 (Meaning and Semantic Composition) and Chapter 10 (Information Structure). In our discussion of grammatical phenomena in Part III of this book, we do not provide an analysis of the prosodic aspects of the constructions we examine, and so readers who are not concerned with prosodic structure and its place in the architecture of LFG can skip this chapter.

- Chapter 12 (The Interface to Morphology) discusses the morphological component and its place in the grammar of LFG. It does not presuppose any of the other material in Part II. Since we do not rely on a particular view of the morphological component of the grammar in Part III of this book, this chapter can be skipped by readers who are not concerned with issues of word formation and morphological analysis.

Full familiarity with the issues covered in Part II is not necessary for an understanding of the discussion in Part III of this book. In fact, the syntactic discussion in Part III depends only on the material presented in Part I, and so readers who are interested only in syntactic analysis can skip all of the chapters in Part II.

7

BEYOND C-STRUCTURE AND F-STRUCTURE: LINGUISTIC REPRESENTATIONS AND RELATIONS

In Part I, we provided evidence for two levels of syntactic structure: an abstract representation of functional syntactic organization, the f-structure, and a separate level of phrasal organization, the c-structure. These linguistic structures are represented in different ways: by means of a phrase structure tree for c-structure, and by an attribute-value structure for f-structure. Besides these two syntactic structures, LFG research has explored other linguistic levels and their representations. As with the relation between c-structure and f-structure, it is possible to define and constrain these additional linguistic levels by specifying properties of their structure and their relation to other levels of structure. In considering the overall architecture of our theory of grammar, we must address the following questions: How do we determine when it is necessary to postulate the existence of a new linguistic level, distinct from those already assumed within the theory? How do we determine the best representation for a proposed level of structure? And how can constraints within a level, or constraints that hold across levels, be defined within this architecture? Our theory must respect modularity and the independence of different levels of linguistic structure, while stating the relations among levels in a clear and easily understandable way.

1. LINGUISTIC STRUCTURES AND MODULES

1.1. Defining a Separate Structure

In the analysis of new and unfamiliar linguistic phenomena, it is sometimes tempting to assume that they constitute a new and independent linguistic system, governed by its own rules, rather than simply hitherto unexplored manifestations of familiar phenomena and familiar rules. Whether or not to propose a distinct representation for a new type of linguistic information must be considered carefully. Sadock (1991, pages 214-215) suggests that:

> Any postulated component should be of a kind that one might want in a full description of the basic facts of language, regardless of the way in which the modules are related to one another.

It is difficult to provide strict criteria for when it is appropriate to postulate the existence of a separate level. Sadock (1991, page 215) rightly cautions against assuming "levels that are entirely abstract," encoding relations like coindexing or traces; of course, any new level that is postulated should deal with a coherent set of linguistic phenomena that are found in multiple languages and are demonstrably and cohesively related to one another.

For example, there has been some disagreement about the status of f-structure as a grammatical level of structure, and what information should be represented there. As we discuss in Chapter 12, Section 2.2, Frank and Zaenen (2002) make the strong claim that f-structure should not contain features that vary from language to language, such as CASE and agreement features; instead, it should contain all and only the features that are relevant for semantic interpretation. On their view, features that are not semantically relevant should be represented in a separate *morphosyntactic structure*; indeed, Frank and Zaenen advocate thinking of f-structure as an underspecified semantic representation, analogous to the unscoped, purely semantic representation Quasi-Logical Form in the Core Language Engine language processing system (Alshawi 1992). Falk (2003) provides convincing argumentation against this approach, however: on Falk's view, f-structure is not a semantic structure but a syntactic structure, and it is the appropriate place to represent morphosyntactic features that play a role in the grammar of a language (see Dyvik 1999 for an articulate defense of a similar view). In Chapter 12, we provide further discussion of approaches which assume a separate level of morphosyntactic structure, but we do not assume this level of structure in this book.

1.2. Defining a New Relation on an Existing Structure

With advances in our understanding of the overall grammatical architecture and the interactions among levels, phenomena previously analyzed in terms of one level of linguistic structure may be open to analysis in terms of a new relation defined at another level. Compare, for example, the original treatment of long-distance dependencies at c-structure, by means of the double-arrow annotation relating two c-structure positions (Kaplan and Bresnan 1982), with the currently accepted analysis of long-distance dependencies as relating f-structure roles rather than c-structure positions by means of *functional uncertainty* (Kaplan et al. 1987).[1]

In some cases, constraints on grammatical phenomena may involve more than one kind of linguistic information; such constraints must be stated by reference to more than one aspect of linguistic structure. This in itself does not constitute motivation for introducing a new grammatical module incorporating information from other levels. Indeed, many phenomena that we have already examined are of this nature. For example, the correlation between phrase structure positions and grammatical functions involves reference both to c-structure and to f-structure, and is captured by annotations on c-structure rules making reference to f-structure roles.

A fruitful strategy for the formal treatment of linguistic phenomena involving relations and entities at more than one level of representation is to define a new relation on an existing structure in terms of relations that are native to another structure. An example of this is *functional precedence*, a relation between f-structures that is defined in terms of the precedence relation that holds between c-structure nodes (Chapter 6, Section 11.4). Defining a precedence relation derivative of c-structure properties on the f-structure, a level at which precedence is not native, gives rise to very interesting results that are not available when the standard c-structural precedence relation is considered. In particular, f-structures that do not correspond to any c-structure nodes also take part in f-precedence. Additionally, nonadjacent constituents in different parts of the phrase structure tree may correspond to the same f-structure, and thus the c-structure nodes corresponding to a single f-structure may be interleaved with the nodes of another; in this case, no f-precedence relation may hold between the two f-structures. Thus, constraining precedence relations in terms of f-precedence instead of c-structure precedence gives rise to a richer set of predictions for how the linear order of arguments can be constrained.

The principle of modularity is a central tenet of LFG. We explore this in the next section.

2. MODULARITY

Analyzing an utterance requires the linguist to analyze different types of linguistic structure and information; a modular approach requires different aspects of linguistic structure to be represented as distinct, independent components of the grammar. These separate components or *grammatical modules* each have

[1] For more on the history of the treatment of long-distance dependencies in LFG, see Dalrymple et al. (1995d); we discuss long-distance dependencies in detail in Chapter 17.

their own primitives and organizing principles, and therefore their own internal structure and formal representation. For instance, a concept such as "noun phrase" is relevant at the level of c-structure, but not f-structure; similarly, syllables are important in a phonological analysis, but a semantic analysis of an utterance is effectively blind to them.

A modular approach ensures that different types of linguistic information are not conflated. This enables generalizations, whether universals or language-particular constraints, to be stated for and apply only to the level of representation for which they are relevant. Moreover, separating parts of the grammar in this way minimizes the possibility of adverse effects should it become necessary to modify the analysis of one component of the grammar: advances in the analysis of one aspect of linguistic structure can be incorporated into the model without the need for a wholesale revision of the grammatical architecture. This ensures that LFG's approach to the architecture of the grammar is stable yet flexible.

While the different modules of the grammar are separate in LFG, they exist in parallel. This does not entail a one-to-one correspondence between the subparts of structures at any of the levels, nor does it mean that the information encapsulated within one module (for example, the precedence relation between c-structure nodes) is unavailable to another. Indeed, distinct structural levels are *mutually constraining*, and analyses can be formulated which capture interactions among syntax, semantics, prosody, information structure, and other levels. Universal and language-particular generalizations about the interface between specific modules of the grammar can also therefore be stated without requiring that such generalizations apply to all modules or inter-modular relations.

3. THE PROJECTION ARCHITECTURE

Kaplan (1987) originally proposed the *projection architecture* to define piecewise correspondences between grammatical modules (see also Halvorsen and Kaplan 1988). The different modules are also referred to as *projections*, and the functions relating the structures are referred to as *correspondence functions*.

We are already familiar with the basic concepts of the projection architecture from our study of the relation between c-structure and f-structure. Chapter 5, Section 3.1 presented a notation for referring to the current c-structure node and its mother:

(1) the current c-structure node ("self"): $*$
the immediately dominating node ("mother"): $\hat{*}$

The correspondence function ϕ relates nodes of the c-structure to their corresponding f-structures, as described in Chapter 4. To recap briefly, $\phi(*)$ is the f-structure corresponding to the node under consideration, and $\phi(\hat{*})$ is the f-structure corresponding to its mother node. A standard abbreviation for $\phi(\hat{*})$ is $\uparrow$; a standard abbreviation for $\phi(*)$ is $\downarrow$. Alternative notations for correspondence functions have also been proposed; in some work, correspondence functions are represented as a subscript, with $*_{\phi}$ used as an alternative notation for $\phi(*)$. This notation is particularly common in discussions of structures projected from the f-structure, and we will adopt this variant notation in Chapter 8 in our discussion of semantic structure, and in subsequent chapters. In this chapter, for explicitness, we represent correspondence functions in the mathematically more standard way: for example, $\phi(*)$ and $\phi(\hat{*})$.

Just as the correspondence function ϕ relates c-structure nodes and f-structures, other functions can be defined to relate other aspects of linguistic organization. We can define a relation between modules by specifying a function relating parts of any linguistic structure to parts of another. For example, a function σ relating f-structures to semantic structures can be defined, as we will see below and in Chapter 8. In this way, LFG models distinct aspects of linguistic structure, including but not limited to syntactic structures, and the mappings between them.

There is a clear relation between LFG's projection architecture and other formal linguistic architectures. For example, Head-Driven Phrase Structure Grammar (Pollard and Sag 1994; Sag et al. 2003) and related theories encode linguistic information as a single structure, the *sign*, represented as an attribute-value structure like the f-structure. Subparts of the sign correspond to different aspects of linguistic structure, and the various substructures are built up simultaneously. A linguistic structure that is represented as an attribute-value structure and defined as a projection of the f-structure can be represented in an equivalent but less revealing way as a subpart of the f-structure it is associated with: the function defining the relation between the f-structure and the new projection can be reinterpreted as an attribute of the f-structure, with the new structure as its value. The significance of the projection architecture lies not in the additional formal power that it brings, but in its expressiveness and modularity; it allows for the relation between different linguistic components to be expressed while also retaining the identity of these components as separate structures representing different kinds of linguistic information. The resulting grammatical architecture respects the principle of modularity.

4. DEFINING RELATIONS BETWEEN STRUCTURES

Kaplan (1995) notes that there are two ways in which relations between structures can be defined: *codescription* and *description by analysis*. The formal difference between these two methods of description has not yet been fully explored. Ron Kaplan (p.c.) hypothesizes that description by analysis is the more powerful of the two, but a complete formal analysis and proof awaits further research.

4.1. Description by Analysis

Relations between structures can be defined by *description by analysis*, in which a description of one structure is obtained by analysis of another structure. A number of LFG proposals for semantic analysis and representation involve description by analysis: for instance, Halvorsen (1983) defines a semantic structure for an utterance on the basis of properties of its f-structure. Chapter 8 presents a theory of the syntax-semantics interface that differs from Halvorsen's proposals in a number of respects, and the theory presented there will be used in semantic analyses of the phenomena treated in the remainder of the book. Here we present Halvorsen's theory of the syntax-semantics interface as a particularly clear example of description by analysis.

Description by analysis involves the definition of properties of one structure based on the properties of another. Informally, a rule using description by analysis says something like: "whenever there is a structure with a certain property, it corresponds to another structure of a certain type."

Halvorsen presents the following partial table of correspondences between semantic forms in the f-structure and meanings, represented as logical formulas:[2]

(2)

Semantic form in f-structure:	Meaning:
'EVERY'	$\lambda R.\lambda S.every(R, S)$
'HORSE'	$\lambda x.horse(x)$

Halvorsen also presents a set of rules for determining the meaning of an f-structure based on its semantic forms. The following is a simplified version of his Rule III, SPEC-PRED configuration, which defines the meaning M_k of an f-structure f_k:

(3) SPEC-PRED configuration:

If f_k is an f-structure of the form $\begin{bmatrix} \text{SPEC} & v_1 \\ \text{PRED} & v_n \\ \vdots & \vdots \end{bmatrix}$, then

$(M_k\ \text{PREDICATE}) = \lambda P.\lambda Q.Q(P)$
$(M_k\ \text{ARG1}) = M_1$ (semantic structure of the SPEC)
$(M_k\ \text{ARG2}) = M_2$ (semantic structure of the PRED)

Let us see how this rule operates in the analysis of the f-structure proposed by Halvorsen for the noun phrase *every horse*. For this simple example, we will leave out most of the detail in the f-structure:

(4) F-structure for *every horse* according to Halvorsen (1983):

$f_1\begin{bmatrix} \text{SPEC} & \text{EVERY} \\ \text{PRED} & \text{`HORSE'} \end{bmatrix}$

[2]Halvorsen's analysis has been considerably simplified for presentation here, leaving aside many of the details of the meanings and rules that he proposes. Further, we have modified his analysis by assuming that a word like *every* is treated as a *generalized quantifier* (Barwise and Cooper 1981) specifying that the *every* relation holds between two properties R and S. We discuss quantification in more detail in Chapter 8. The lambda operator λ is explained in Chapter 8, Section 4.1.

We apply the rule in (3) in the following way. First, we inspect the f-structure in (4), noting that it is of the form required by the rule in (3). Therefore, we introduce a constraint on the structure M_1, the semantic structure corresponding to f_1: it must contain the attribute PREDICATE with value $\lambda P.\lambda Q.Q(P)$. We also add the additional constraint that M_1 must contain the attribute ARG1, and we determine the value of that attribute by consulting the table in (2); in a similar way, we add a constraint on the value of ARG2. This yields the following set of constraints on M_1:

(5) $(M_1\ \text{PREDICATE}) = \lambda P.\lambda Q.Q(P)$
$(M_1\ \text{ARG}1) = \lambda R.\lambda S.\mathit{every}(R, S)$
$(M_1\ \text{ARG}2) = \lambda x.\mathit{horse}(x)$

These equations describe the following semantic structure M_1 for the f-structure f_1:

(6)
$$M_1\begin{bmatrix} \text{PREDICATE} & \lambda P.\lambda Q.Q(P) \\ \text{ARG}1 & \lambda R.\lambda S.\mathit{every}(R, S) \\ \text{ARG}2 & \lambda x.\mathit{horse}(x) \end{bmatrix}$$

We also need a set of rules for interpreting this structure: Halvorsen (1983) presents a set of rules that produce logical formulas from these semantic structures. Among them are rules like the following:

(7) PREDICATE and ARG_i

Apply the PREDICATE to ARG_n, where n is the polyadicity of the predicate. Apply the result to ARG_{n-1} and so on, until $n = 0$.

Applying this rule to the semantic structure for *every horse* in (6) produces the following result, which is just what is required for the phrase *every horse*:

(8) $\lambda P.\lambda Q.[Q(P)](\lambda x.\mathit{horse}(x))(\lambda R.\lambda S.\mathit{every}(R, S))$
$= \lambda S.\mathit{every}(\mathit{horse}, S)$

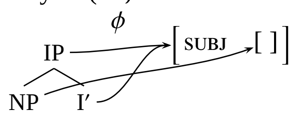
In sum, linguistic analyses formulated according to the description-by-analysis paradigm operate by imposing constraints on one structure on the basis of an inspection of one or more other structures.

4.2. Codescription

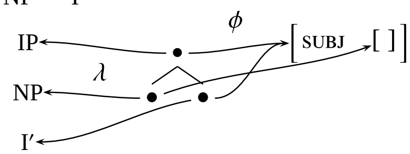
Grammatical structures can also be related by *codescription*, where multiple structures are simultaneously described; this is the most common way in which the relations between grammatical modules are encoded and constrained. For example, annotated c-structure rules simultaneously encode constraints on (at least) two kinds of grammatical information: c-structure category and f-structure.

As discussed in Chapter 5, Section 1.2, nodes of the c-structure tree are associated with two different functions: the ϕ function relates c-structure nodes to their corresponding f-structures, and the λ function relates nodes to their labels. We can represent the configuration in (9a) in a more explicit but also more cumbersome way as (9b):

(9) a.



b.



The trees in (9) are licensed by the phrase structure rule in (10a), which is equivalent to the rule in (10b) except that the λ labeling function is explicitly shown, and $\phi(\hat{*})$ and $\phi(*)$ appear rather than the abbreviatory $\uparrow$ and $\downarrow$ arrows in the former. The format in (10a) makes it clear that two different aspects of structure are constrained by this rule. The λ labeling function constrains the phrase structure category of the mother and daughter nodes,[3] and the ϕ function constrains the f-structures that correspond to the mother and daughter nodes. In other words, this rule simultaneously describes, or *codescribes*, two levels of structure: the ϕ projection from c-structure — that is, the f-structures $\phi(\hat{*})$ and $\phi(*)$, and the λ projection from c-structure nodes defining the category of the node.

(10) a.

$$\bullet \longrightarrow \begin{array}{c} \bullet \\ \lambda(*) = \mathrm{NP} \\ (\phi(\hat{*})\ \textsc{subj}) = \phi(*) \end{array} \quad \begin{array}{c} \bullet \\ \lambda(\hat{*}) = \mathrm{IP} \\ \lambda(*) = \mathrm{I}' \\ \phi(\hat{*}) = \phi(*) \end{array}$$

b.

$$\mathrm{IP} \longrightarrow \begin{array}{c} \mathrm{NP} \\ (\uparrow \textsc{subj}){=}\downarrow \end{array} \quad \begin{array}{c} \mathrm{I}' \\ \uparrow{=}\downarrow \end{array}$$

5. DEFINING INTERSTRUCTURAL CONSTRAINTS

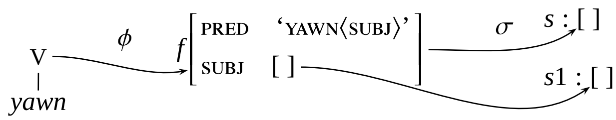
It is often useful to refer to the relation between one representation and another: to speak, for example, of the semantic structure that corresponds to a particular c-structure node. In order to achieve this, we need to be able to talk about the relation between two structures related by functional projections.

[3]The constraint $\lambda(\hat{*}) = \mathrm{IP}$ defining the category of the mother node could have been written on either daughter node: here we have made the arbitrary decision to associate it with the second daughter.

5.1. Structural Correspondence by Composition

In Chapter 8, we will introduce *semantic structure* as a level of linguistic structure directly related to f-structure; the correspondence function σ relates f-structures to semantic structures in the following way:

(11)



In the configuration depicted in (11), the correspondence function ϕ relates the c-structure node labeled V to the f-structure labeled f. The σ function defines a direct relation between f-structures and semantic structures: in (11), the semantic structure corresponding to f is labeled s, and the semantic structure corresponding to f's subject is $s1$. The following facts hold of the configuration in (11):[4]

(12) $\phi(\mathrm{V}) = f \qquad \sigma(f) = s$

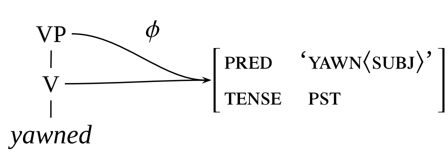
Given the functions ϕ and σ, we can define a function between c-structure nodes and semantic structures as the *composition* of the two correspondence functions, $\sigma \circ \phi$.[5] In the case at hand, we can apply the composition function $\sigma \circ \phi$ to the c-structure node V to get the semantic structure s:

(13) $\sigma \circ \phi(\mathrm{V}) = \sigma(\phi(\mathrm{V})) = \sigma(f) = s$

In this way, using codescription, we can define a function between c-structure nodes and their corresponding semantic structures that is mediated by the f-structure in terms of the function ϕ from c-structure nodes to f-structures and the function σ from f-structures to semantic structures. More generally, we can exploit the projection architecture to define relations between structures that are not directly related via correspondence functions by defining new composite functions to relate the two levels.

Subtle issues arise in the design of the optimal projection architecture for linguistic description. In particular, care must be taken in arranging the various linguistic structures properly, since distinctions that are relevant at one level but collapsed at another cannot be reintroduced in further projections. Consider this configuration:

(14)



[4] As mentioned in Section 3 of this chapter, an alternative subscript notation f_σ, exactly equivalent to $\sigma(f)$, is often used for semantic structures.

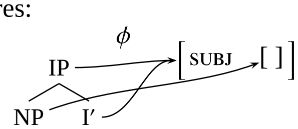
[5] The *composition* of two functions is obtained by taking the result of applying one of the functions to its argument and then applying the other function to that result (see Partee et al. 1993, page 33). The composition of two functions is also a function.

At c-structure, the distinction between the nodes labeled VP and V is clearly represented: two different c-structure nodes are involved. At f-structure, the distinction between the two nodes is collapsed, since the two nodes correspond to the same f-structure. Thus, any level of linguistic representation that must make reference to a distinction between the V and the VP node cannot be a projection of the f-structure, since the distinction between VP and V is collapsed at that level and cannot be reintroduced in projections from the f-structure.

5.2. Structural Correspondence by Inverse Correspondence

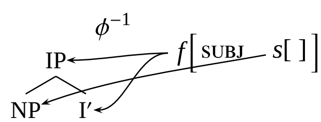
This diagram depicts the familiar ϕ function from nodes of the c-structure to f-structures:

(15)



In Chapter 6, Section 10.3, we discussed *inverse correspondences* between structures. The inverse of the ϕ function, ϕ^{-1}, relates f-structures to the c-structure nodes that correspond to them:

(16)



In the configuration depicted in (16), the f-structure labeled f is related via the ϕ^{-1} correspondence to two c-structure nodes, labeled IP and I′, and the SUBJ f-structure is related via the ϕ^{-1} correspondence to the node labeled NP. The definition of the CAT predicate (given in (157) of Chapter 6 [page 267]) is stated in terms of the inverse of the ϕ function, ϕ^{-1}:

(17) Definition of CAT:

CAT(f, C) if and only if $\exists n \in \phi^{-1}(f) : \lambda(n) \in C$.

The inverse correspondence is not in general a function, as noted in Chapter 6, Section 10.3: there are often several c-structure nodes that correspond to a particular f-structure. In (16), for example, the IP and I′ nodes of the c-structure tree are related to the same f-structure f:

(18) $\lambda(\phi^{-1}(f)) = \{\text{IP}, \text{I}'\}$

Thus, the projection architecture allows for the statement of complex relations among linguistic structures, and for constraining these relations in appropriate ways.

6. REPRESENTING LINGUISTIC STRUCTURE AND INFORMATION

LFG shares with a number of linguistic theories the view that functional, configurational, and other linguistic structures reflect what Sadock (1991) calls "parallel organizational principles": the various facets of linguistic organization are copresent, and each aspect of linguistic structure is organized according to its own set of rules and principles. LFG assumes a fine-grained relation between representations in which subparts of one module are related to subparts of another one; for instance, as the c-structure is related to the f-structure. Wellformedness is defined and determined for each module: what holds for one module need not necessarily hold for another, even if their representation is similar.

Other grammatical theories also resemble LFG in taking the view that representations of different aspects of linguistic structure need not be of the same formal types. The formal architecture of Construction Grammar as described by Kay (2002), in which the syntactic objects are trees whose nodes are associated with feature structures, is fairly close to that of LFG. In Role and Reference Grammar (Van Valin 2003), a semantic/logical structure resembling a formula of predicate logic is linked to a layered, tree-like syntactic structure via a set of linking rules. Some versions of Categorial Grammar also allow linguistic representations of different formal types; Oehrle (1999) provides a view of LFG as labeled deduction in categorial terms (Gabbay 1996), where the correspondences between different structures are represented as relations between labels on formulas. The Parallel Architecture theory of Culicover and Jackendoff (2005) and Jackendoff (2002, 2010) assumes an architecture in which phonological, syntactic, and semantic information is organized into separate modules, each module consisting of a set of tiers which may have different formal representations.

In adhering to the principle of modularity, LFG differs from frameworks which, to a greater or lesser extent, seek to conflate different types of linguistic information by using the same primitives, organizing principles and formal representations to model syntax and semantics (as in some versions of Chomskyan transformational theories) or syntax and phonology/prosody (as in Head-Driven Phrase Structure Grammar).

Does it matter how linguistic structure is represented and how the different facets of structure are related? In fact, this issue is vitally important: the use of inappropriate representations and relations makes it difficult to capture facts about the linguistic structure underlying the representations, and can lead to incorrect and obscured views of linguistic typology. In LFG, the choice of how to represent a particular kind of information is made on the basis of how that kind of information is best expressed.

For instance, dominance and precedence conditions and phrasal groupings are clearly and succinctly represented in terms of a familiar phrase structure tree, the c-structure. In the case of functional syntactic information, however, a phrase structure tree is not the best way of perspicuously and unambiguously representing this information, as trees carry with them certain presuppositions about the information being represented. For instance, trees encode a linear order, which does not make sense in the functional realm; further, nodes in a tree are required to have a single mother, which, if used in f-structure, would imply that a phrase can play only a single functional role. Instead, as originally proposed by Kaplan (1975a,b), an attribute-value structure is a very good way of representing functional information and is therefore the way in which functional structure is represented in LFG. The functional structure does not contain information about linear order relevant for the description of constituent structure but irrelevant to functional organization. In addition, the fact that a single f-structure may be the value of more than one functional structure attribute allows us to represent the fact that a single phrase may play multiple functional roles (see Chapter 2, Section 4).

Conversely, we might regain representational uniformity by representing phrase structural information in the same way as the f-structure, by means of an attribute-value structure. In fact, a tree is nothing more than a special kind of attribute-value structure: one in which a linear ordering between nodes is imposed, so that a node can be said to precede or follow another node; cycles are disallowed, so that a node cannot both dominate and be dominated by another node; and values of attributes may not be shared.

However, representing phrase structure information in terms of attribute-value structures has the potential for leading to confusion. The same formal properties that render trees an inappropriate representation for functional information make them a very good representation for phrase structure information. Attribute-value structures are not inherently ordered, and they allow a node to have more than one mother. On the other hand, the words of an utterance do appear in a particular order, and (on most theories of phrase structure organization) a c-structure node cannot be dominated by more than one mother node.[6] The particular characteristics of phrase structure are concisely and intuitively captured by a phrase structure tree, not an attribute-value representation.

Other linguistic information might be best represented in terms of other kinds of formal structures. For instance, as we will see in Chapter 8, a deductive semantic approach meshes well with the overall LFG architecture; such an approach is well suited to the expression of meanings in terms of formulas in a logical language like those standardly used in formal semantic theory. On the LFG view, the representation of each type of linguistic information by means of structures that reflect the nature of that information allows for a systematic, flexible, and principled account of relations between modules, promotes clear intuitions about the formal and linguistic properties of each module, and aids in developing reasonable ways of thinking about interactions between modules.

In the remainder of Part II of this book, we will present the different linguistic modules which the LFG projection architecture comprises, exploring their representation and how they are related to one another by correspondence functions.

[6]Some approaches allow phrase structure trees that violate some of these formal conditions; see, for example, McCawley (1988). McCawley's trees are, then, a more abstract representation of syntactic information than the constituent structures of LFG.

7. FURTHER READING AND RELATED ISSUES

Some early LFG work does not assume a projection architecture, but makes other assumptions about the representation of the various aspects of linguistic structure and how they are related. For example, Fenstad et al. (1987) outlined a proposal for the architecture of LFG that involves codescription and that differs significantly in its formal architecture from standard LFG approaches; Fenstad et al.'s approach was independently developed at about the same time as the early development of Head-Driven Phrase Structure Grammar (Pollard and Sag 1994), and it formally resembles HPSG much more closely. Besides the c-structure tree, Fenstad et al. propose a bipartite structure consisting of a syntactic representation like the f-structure and a semantic representation in attribute-value format. Additionally, they propose that other levels of structure, such as phonological structure, are also represented as subparts of the overall structure. The following is their representation of the semantic and syntactic structure for the sentence *John walks*:

(19)
$$\left[\begin{array}{ll}
\textsc{sitschema} & \left[\begin{array}{ll}
\textsc{rel} & \textit{walk}\\
\textsc{arg}.1 & \left[\begin{array}{ll}\textsc{ind} & \textit{John}\end{array}\right]\\
\textsc{loc} & \left[\begin{array}{ll}\textsc{ind} & \textsc{ind}.1\\ \textsc{cond} & \left[\begin{array}{ll}\textsc{rel} & \circ\\ \textsc{arg}.1 & [\;]_1\\ \textsc{arg}.2 & l_d\end{array}\right]\end{array}\right]\\
\textsc{pol} & 1
\end{array}\right]\\
\textsc{fstruct} & \left[\begin{array}{ll}
\textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{John}\text{'}\\ \textsc{num} & \textsc{sg}\end{array}\right]\\
\textsc{tense} & \textsc{prs}\\
\textsc{pred} & \text{`}\textsc{walk}\langle\textsc{subj}\rangle\text{'}
\end{array}\right]
\end{array}\right]$$

Andrews and Manning (1999) also present a very different view of the relations between linguistic structures within the LFG framework, an approach that formally resembles the work of Fenstad et al. (1987) as well as work in HPSG.

Andrews (2008) proposes a view of semantic structure and the syntax-semantics interface which, unlike the codescription approach to be presented in Chapter 8, proposes that semantic structure and semantic constraints are established on the basis of description by analysis of the f-structure. Andrews motivates this alternative analysis by providing a set of arguments against the standard codescription approach and in favor of his description-by-analysis alternative. Though we do not adopt his analysis in this book, it is interesting as an alternative view of how different aspects of linguistic structure are related.

In our discussion of linguistic modules, we will not touch on proposals for enriching the projection architecture to enable the analysis of multimodal communication: see Giorgolo and Asudeh (2011b) for a very interesting proposal to augment the projection architecture to account for the role that gestures (specifically, spontaneous hand gestures) may play in interpretation.

8

MEANING AND SEMANTIC COMPOSITION

We now embark on an exploration of the theory of the relation between syntax and meaning, examining how the meaning of an utterance is determined on the basis of its syntactic structure. Early work in LFG proposed that the semantic form value of the f-structure PRED represented certain aspects of the meaning of the f-structure. Later work assumes the existence of a separate level of *semantic structure* or *s-structure*, related to the f-structure by a correspondence function. In this chapter, we briefly review some previous LFG approaches to semantics and the syntax-semantics interface. We then present the *glue approach* to semantic composition. This approach, which we adopt in the rest of the book, provides a firm theoretical foundation for the discussions and analyses that we present.

1. SYNTAX AND SEMANTIC INTERPRETATION

The central problem of semantic interpretation is plain: people have no trouble understanding the meanings of sentences in their language that they have never heard before. Thus, it must be possible to determine the meaning of a novel sentence on the basis of the meanings of its component parts. The idea that the meanings of larger pieces are assembled from the meanings of the smaller pieces that make them up is known as the *Principle of Compositionality*, and is generally attributed to Gottlob Frege (though the accuracy of this attribution has been disputed; see, for example, Janssen 1997, 2001). An adequate treatment of linguistic meaning requires, then, a theory of the meanings of the most basic units of a sentence, together with a theory of how these meanings are put together.

A commonly accepted version of the Principle of Compositionality is the *rule-to-rule* hypothesis, which states that "a very close relation is supposed to exist between the rules of the syntax and the rules of the semantics" (Bach 1989, page 124). This means that each syntactic rule for combining syntactic units to form a larger syntactic unit corresponds to a semantic rule that tells how to put the meanings of those units together to form the meaning of the larger unit. The syntactic rules in question are often assumed to be phrase structure rules, so that instructions for combining meanings are paired with instructions for forming constituent structure phrases.

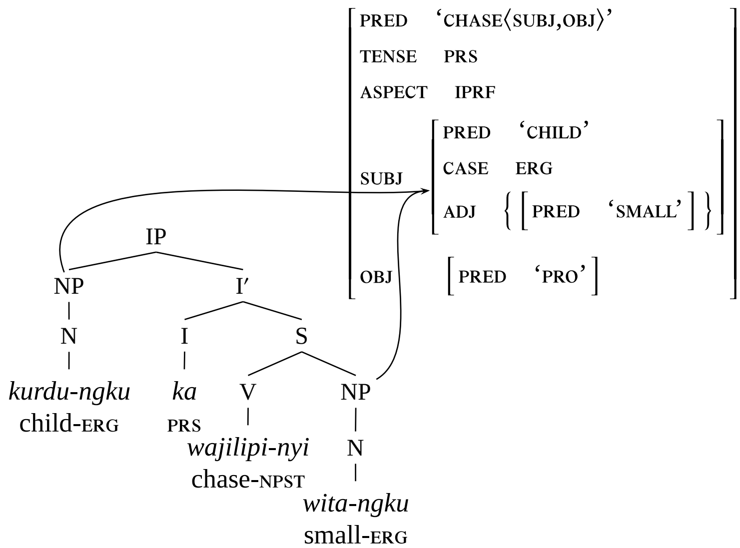
However, this version of the rule-to-rule hypothesis is actually just one way of enforcing an orderly theory of semantic composition, one in which the intuition that the meaning of a whole depends on the meanings of its parts is made explicit by defining the relevant parts as phrase structure constituents. In fact, research on the syntax-semantics interface and semantic composition in LFG has shown that we can remain faithful to the Principle of Compositionality without assuming that rules for putting meanings together must depend on phrasal primitives such as linear order and phrasal dominance.

Since the inception of semantic research in LFG, convincing arguments have been made that semantic composition should proceed mainly by reference to functional structure rather than constituent structure organization. As argued by Fenstad et al. (1987, Chapter 2), the units that are primarily relevant for semantic composition are units at f-structure and not necessarily at c-structure. For example, as we have seen, a semantic unit may correspond to discontinuous portions of the c-structure tree. Example (32) in Chapter 4, repeated as (1) below, shows that the Warlpiri analog of the English phrase *small child* need not form a c-structure constituent; the noun *kurdu-ngku* 'child' appears at the beginning of the sentence, while its modifier *wita-ngku* 'small' appears at the end.

However, rules for semantic composition in both Warlpiri and English treat the subject of the Warlpiri sentence *kurdu-ngku ka wajilipi-nyi wita-ngku* and that of the English sentence *The small child is chasing it* as an f-structure constituent and as a semantic unit; in fact, the rules for semantic composition in the two languages are remarkably similar, considering the great differences between the two languages at the c-structure level. Guiding semantic composition by reference to f-structure and not c-structure relations brings out and clarifies crosslinguistic commonalities in principles of semantic composition, commonalities that would otherwise be obscured by properties of the more variant c-structure.

Even given the centrality of f-structure in semantic composition, however, it must be kept in mind that semantic composition does not depend upon f-structure relations alone. For example, as pointed out by Halvorsen (1983) and Fenstad et al. (1987), prosody has a strong effect in determining semantic interpretation.

(1) *kurdu-ngku ka wajilipi-nyi wita-ngku*
child-ERG PRS chase-NPST small-ERG
'The small child is chasing it.'



Prosodic information is represented at prosodic structure, a structure that is related to but separate from the c-structure; the modeling of prosodic influence on semantic interpretation is explored in Chapter 11. Information structure, described in Chapter 10, is also closely connected to semantic interpretation. In the rest of this chapter we will not examine constraints on meaning assembly imposed at nonsyntactic levels of representation, leaving discussion of these issues for Chapter 10 and Chapter 11.

2. SEMANTIC FORMS

As discussed in Chapter 2, Section 4.1, the value of the PRED feature in the f-structure is called a *semantic form*. This nomenclature reveals an early LFG view of meaning and its relation to f-structure: semantic forms were originally seen as the locus of semantic representation. On the view presented by Kaplan and Bresnan (1982), semantic forms represent four types of information (see also Dalrymple et al. 1993 and Kuhn 2001c):

(2) a. Specification of the semantic relation
b. Mapping of grammatical functions to semantic roles

c. Subcategorization information (the governed grammatical functions)

d. Instantiation to indicate distinctness (predicate uniqueness)

This assumes a semantic form like the one in (3) for the verb *give*:

(3) Semantic form for *give* (Kaplan and Bresnan 1982):

$$\text{`give}\langle \underset{\text{AGENT}}{\overset{\text{SUBJ}}{—}}, \underset{\text{THEME}}{\overset{\text{OBJ}}{—}}, \underset{\text{GOAL}}{\overset{\text{OBL}_{\text{GOAL}}}{—}} \rangle\text{'}$$

This semantic form specifies that the predicate *give* has three arguments with roles AGENT, THEME, and GOAL; that the AGENT is mapped to SUBJ, the THEME is mapped to OBJ, and the GOAL is mapped to OBL_{GOAL}; that the f-structure for a sentence with this verb must contain a SUBJ, an OBJ, and an OBL_{GOAL} in order for Completeness and Coherence conditions to be met; and that this use of the verb *give* is distinct from other uses of the same verb, since each use of a semantic form is uniquely indexed (Chapter 5, Section 2.2.1).

More elaborated theories of several of these aspects of semantic forms have emerged in the years since Kaplan and Bresnan's original work. Most obviously, the mapping of grammatical functions to semantic roles has been the focus of much theoretical attention; this is discussed in detail in Chapter 9. Further, the semantic form is no longer assumed to represent semantic relations. Instead, the semantic contribution of a verb like *give* is reflected in the semantic structure and its relation to meaning (to be described in this chapter), as well as in argument structure (Chapter 9). This separation leads to a more modular theory, since on this view f-structure is a purely syntactic level of representation, not a mix of syntactic and semantic information (on modularity, see Chapter 7, Section 2). In addition, a more adequate view of meaning and its relation to syntax is thereby available: the original view of the semantic form was inadequate to represent anything but the most basic semantic relations. Semantic forms could not represent many aspects of interpretation, including scope of modifiers, quantification, and notions of coreference.

What, then, is the role of the semantic form value of the PRED feature in the current setting? First, the function of instantiation to indicate distinctness remains. Many words make a syntactically unique contribution, and the fact that semantic forms are instantiated uniquely for each instance of their use is a formal reflection of this.

Second, semantic forms represent the array of syntactic arguments that a predicate requires, making explicit the result of the application of mapping principles to the argument structure of a predicate. As we discuss in Chapter 9, syntactic and semantic argument structure are not the same; verbs like intransitive *eat* and *rain* illustrate this point:

(4) a. *Chris ate.*

b. *It rained.*

Although *eat* denotes a two-place relation between an eater and an eaten thing, syntactically it has an intransitive use, as shown in (4a); conversely, *rain* does not take a semantic argument, but is syntactically monovalent. Semantic forms represent the syntactic grammatical functions required by a predicate, whether or not they make a semantic contribution. Andrews (2008) provides further discussion of the role of semantic forms in LFG.

3. SEMANTIC STRUCTURE AND MEANING COMPOSITION

Approaches to semantics and the syntax-semantics interface within the LFG framework share a striking degree of commonality: rules for semantic composition are formulated primarily by reference to syntactic predicate-argument structure, the syntactic organization of f-structure; and a theory of either implicit or explicit instructions for combining the meanings of the parts of a sentence into the meaning of the whole — what Fenstad et al. (1987) call a "logical syntax" — is based on these f-structure relations.

In the first comprehensive treatment of semantics and its relation to syntax within LFG theory, Halvorsen (1983) proposes a semantic structure that is obtained by analysis of the f-structure, as described in Chapter 7, Section 4.1. Halvorsen's semantic structure consists of instructions on how to assemble meanings represented as formulas of the intensional logic of Montague (1973); thus, the semantic structure represents an explicitly stated and clearly worked out theory of semantic composition, a set of instructions for meaning assembly.

Reyle (1988) provides a different view of semantic composition, one which is in some sense more closely tied to c-structure composition but which is interestingly different from the standard assumptions of the rule-to-rule hypothesis. On Reyle's approach, the meaning contributions of the daughters in a phrase structure rule are gathered up into a set of contributions associated with the mother node. These contributions consist of expressions of intensional logic that are indexed by f-structure relations like SUBJ and OBJ. These contributions can combine in different orders, and these different orders can correspond to different meanings — for instance, to different scopes for quantifiers. This approach is similar in some respects to the treatment of quantifier scope ambiguity described in Dalrymple et al. (1997) and in Section 8 of this chapter: the order in which meanings are combined does not necessarily mirror the order of phrasal composition, and a freer order is allowed.

Wedekind and Kaplan (1993) and Kaplan and Wedekind (1993) present a theory of semantic interpretation that relies on the *restriction operator*, discussed in Chapter 6, Section 9.4. The restriction operator allows reference to the f-structure that results from removing an attribute and its value from another f-structure. Wedekind and Kaplan's analysis is primarily targeted at a treatment of the semantics of modification, which had proven problematic in various ways in previous approaches. An interesting and important aspect of Wedekind and

Kaplan's proposal is that it incorporates a form of *resource accounting*: the semantic argument of a modifier is defined in terms of the meaning that results from removing the modifier from the structure, and the final meaning is obtained by applying the meaning of the modifier to this argument. This means that each modifier is required to make exactly one contribution to the final meaning. In the following, we will see why this property is a particularly desirable one.

These approaches illustrate three important properties of a theory of semantic composition. First, the theory should incorporate a systematic and explicit theory of how meanings combine, grounded in a thorough understanding of the space of theoretical possibilities, structures, and results. Second, it should not impose a particular order of composition that is tied to c-structure organization. Third, it should treat meanings as resources that are accounted for in the course of semantic composition. Section 5 of this chapter introduces an approach to semantic composition and the syntax-semantics interface, the *glue approach*, that meets these conditions. Before introducing the theory, we must decide on a method for representing the meaning of an utterance and its parts; in the next section, we address the issue of meaning representation.

4. EXPRESSING MEANINGS

In formulating a theory of the relation between syntax and meaning, one of the first decisions to be taken is how to represent the meanings of words and phrases. In this book, we concentrate primarily on issues related to semantic composition and the syntax-semantics interface. Many details of semantic interpretation do not interact significantly with principles of meaning assembly and semantic composition; thus, our overall goal is to use the simplest possible meaning representations that are adequate to represent the semantic distinctions in which we are interested.

In Part II of this book, we use standard predicate logic as a way of expressing meanings. This formal system has several advantages: it is a simple and uncluttered representation, and it is widely known and generally familiar. Further, meanings represented as terms of predicate logic can often be readily translated into the representations used in other semantic theories, so that the use of predicate logic is not unduly limiting or confining. In fact, our predicate logic representations might profitably be viewed as abbreviations for the full semantic representations proposed in other semantic theories. Formally, the only requirement we impose on our system of meaning representation is that it must permit function abstraction and application, with a well-defined notion of variable binding, and predicate logic meets this desideratum.

It is of course possible to work within a different, more expressive theory of meaning representation, such as intensional logic (Montague 1973), Discourse Representation Theory (Kamp 1981; Kamp and Reyle 1993), or Situation Semantics (Barwise and Perry 1983). Importantly, these semantic theories are fully compatible with the 'glue' approach to semantic composition that we present here; glue-based approaches to the syntax-semantics interface using intensional logic, Discourse Representation Theory, and Situation Semantics are described in Section 4.2 of this chapter. Indeed, in Part III of the book, we will make use of a version of Discourse Representation Theory rather than predicate logic to express meanings. This is because we require a representation of individuals relevant in the current context, as well as a notion of dynamic variable binding, in order to treat anaphoric relations. Additionally, in our discussion of noun phrase coordination in Chapter 16, we need a basic theory of plurals and group formation, and certain extensions to predicate logic will be necessary. Although we extend our theory of meaning representation beyond simple predicate logic in Part III of the book, the glue approach to semantic composition that we describe in this chapter remains unchanged, since it does not depend on the particular meaning representation that is chosen.

The following few pages contain a brief introduction to some basic concepts of predicate logic. Gamut (1991a,b) and Partee et al. (1993, Chapter 7) give a much more complete explication of the concepts introduced, as well as a full exposition of their formal underpinnings.

4.1. Predicate Logic

The expression in (5) represents the meaning of the proper noun *David*:

(5) *David*

David is a constant representing the individual David. Representing the meaning of a proper noun as an individual constant is a convenient simplification; to do complete justice to the meaning of proper names, a fairly complex theory of individual reference would be required. We stress that such a theory is fully compatible with the glue theory of semantics and meaning assembly that we present, and that the constant *David* can be thought of as an abbreviated representation of the fully fleshed-out semantic contribution of the proper name *David*.

We use the expression in (6) to represent the meaning of the sentence *David yawned*:

(6) *yawn*(*David*)

Formally, the expression in (6) indicates that the one-place function *yawn* is applied to *David* — or, to say the same thing in a different way, the predicate *yawn* holds of *David*. This expression means that David yawned, but does not represent many details of the meaning of the sentence, including its tense. Again, since these details are not immediately relevant to our discussion, we usually omit them. We discuss how the semantics of tense and aspect can be modeled in Section 10 of this chapter.

4.1.1. Lambda Expressions

The expression *yawn* represents a function that takes an argument like *David*. For greater flexibility, we would like to have a general method for constructing functions from other expressions; this is made possible by the use of the *lambda operator* λ, which allows the construction of new functions by abstracting over variables in logical expressions:[1]

(7) Lambda abstraction:

$\lambda x.P$ represents a function from entities represented by x to entities represented by P.

Usually, the expression P contains at least one occurrence of the variable x, and we say that these occurrences are *bound* by the λ lambda operator.

To avoid situations where the same variable name has accidentally been chosen for two different variables, we might sometimes need to rename the variables that are bound by a lambda operator. The expressions in (8a) are equivalent, even though one contains the variable x and the other contains the variable y, and both represent the function *be a person*. Similarly, the expressions in (8b) are equivalent, representing the function *admire oneself*.

(8) a. $\lambda x.person(x) \equiv \lambda y.person(y)$

b. $\lambda x.admire(x, x) \equiv \lambda y.admire(y, y)$

Besides the equivalences that come from variable renaming, there are many other equivalent ways of writing a function. We generally try to represent a function in the clearest way possible, which is usually the simplest and shortest way. For example, in the case of a one-place function like *person*, the shortest and simplest way is just to write the name of the function *person*. Alternatively, we can apply the function *person* to an argument x that is bound by the λ lambda operator, and we have constructed a one-place function $\lambda x.person(x)$ that is the same as the function *person*. The following two expressions are equivalent:

(9) $\lambda x.person(x) \equiv person$

At times it is clearer to write a function in this way; for example, writing the function as $\lambda x.person(x)$ shows explicitly that it is a function that takes one argument.

Another way of thinking of a function like $\lambda x.person(x)$ is that it picks out the set of individuals that are people — that is, the set of individuals x for whom the expression $person(x)$ is true. The function $\lambda x.person(x)$ is called the *characteristic function* of the set of people. We will sometimes refer to sets and their characteristic functions in our discussions of meaning.

[1] A more complete discussion of the lambda operator and the lambda calculus is provided by Gamut (1991b, Chapter 4) and Partee et al. (1993, Chapter 13). Note that this use of λ has nothing to do with the node labeling function λ, discussed in Chapter 5, Section 1.2, nor with the projection function λ assumed in some argument structure work and mentioned in Chapter 9, Section 2.

4.1.2. Function Application

As in (6), we can apply a function to its argument:

(10) Function application:

$[\lambda x.P](a)$

The function $\lambda x.P$ is applied to the argument a.

Square brackets around the function expression have been added to make the groupings in this expression explicit. This expression is equivalent to the expression that results from replacing all occurrences of x in P with a. For example, the expression $[\lambda x.\mathit{yawn}(x)](\mathit{David})$ is equivalent to the expression $\mathit{yawn}(\mathit{David})$, which is the expression that results from replacing all occurrences of x in $\mathit{yawn}(x)$ with *David*:

(11) $[\lambda x.\mathit{yawn}(x)](\mathit{David}) \equiv \mathit{yawn}(\mathit{David})$

There is usually at least one occurrence of x in P. If there is more than one occurrence of x, as in (8b), each occurrence is replaced by the argument of the function.

(12) $[\lambda x.\mathit{admire}(x, x)](\mathit{David}) \equiv \mathit{admire}(\mathit{David}, \mathit{David})$

4.1.3. Types

We assume that the expressions we are working with are typed. As shown earlier, we propose the individual constant meaning *David* for the proper name *David*; this meaning has type e (for *e*ntity), the type of individuals:

(13) $\mathit{David} : e$

The expression in (13) indicates that the constant *David* is of type e. We assume that there are only two basic types: e is associated with individual-denoting expressions, and t (for *t*ruth value) is associated with proposition-denoting expressions, which have a truth value (that is, which are either true or false). The expression $\mathit{yawn}(\mathit{David})$ is of type t:

(14) $\mathit{yawn}(\mathit{David}) : t$

Types of other expressions are built up from these basic types. For example, the type of a one-place relation like *yawn* is:

(15) $\lambda x.\mathit{yawn}(x) : \langle e \rightarrow t \rangle$

The function $\lambda x.\mathit{yawn}(x)$ is of type $\langle e \rightarrow t \rangle$, a function from expressions of type e (represented by x) to expressions of type t (represented by $\mathit{yawn}(x)$).

The type of a two-place relation like *select* is:

(16) $\lambda x.\lambda y.\mathit{select}(x, y) : \langle e \rightarrow \langle e \rightarrow t \rangle \rangle$

This is a function from expressions of type e (represented by x) to functions from expressions of type e (represented by y) to expressions of type t (represented by $select(x,y)$).

The types we have examined so far are:

(17)

expression	type
$David$	e
$yawn(David)$	t
$\lambda x.yawn(x)$	$\langle e \to t\rangle$
$\lambda x.\lambda y.select(x,y)$	$\langle e \to \langle e \to t\rangle\rangle$

As we will see, the type of an argument can be important in constraining possibilities for meaning assembly.

4.1.4. Quantification

Since the work of Montague (1973) and Barwise and Cooper (1981), there has been a great deal of interest in the properties of quantificational words like *every* and *most*. Here we present a brief discussion of quantification; details can be found in Gamut (1991b, Chapter 7), Partee et al. (1993, Chapter 14), Peters and Westerståhl (2006), and Keenan and Westerståhl (2011). In Section 8, we discuss how quantifiers are treated in the glue approach adopted in this work.

The noun phrase *everyone* contains a quantificational meaning corresponding to the determiner *every*. A sentence like *Everyone yawned* has a meaning that can be represented in the following way:[2]

(18) *Everyone yawned.*

$every(x, person(x), yawn(x))$

The quantifier $every$ represents a relation between an individual (here x) and two propositions involving that individual, the proposition $person(x)$ and the proposition $yawn(x)$. The first proposition corresponds to what is often called the *restriction* of the quantifier $every$, and the second proposition corresponds to the *scope*. The type of a quantifier like $every$ is:

(19) $every$: $\langle\langle e \to \langle t,t\rangle\rangle \to t\rangle$

This type associates an individual e with a pair of propositions $\langle t,t\rangle$ that involve that individual. Different quantifiers place different requirements on this relation. For example, for $every(x, person(x), yawn(x))$ to be true, any individual x that is a person — for whom $person(x)$ is true — must also yawn, satisfying $yawn(x)$. In other words, every individual that is a person must also be an individual that yawns.

[2] In our analysis of quantification we use *pair quantifiers* — expressions like the one in (18) — instead of standard generalized quantifiers ($every(person,yawn)$). There is a one-to-one correspondence between the two types of quantifiers, as shown by Dalrymple et al. (1991).

(20) *Most people yawned.*

$\mathit{most}(x, \mathit{person}(x), \mathit{yawn}(x))$

The quantifier *most* requires that more than half of the individuals x satisfying the proposition $\mathit{person}(x)$ must also satisfy the proposition $\mathit{yawn}(x)$.

(21) *No person yawned.*

$\mathit{no}(x, \mathit{person}(x), \mathit{yawn}(x))$

The quantifier *no* requires that any individual x who satisfies the proposition $\mathit{person}(x)$ must *not* satisfy the proposition $\mathit{yawn}(x)$ — that is, there should be no individuals that are people and that also yawn.

The restriction of a quantifier — its first propositional argument — is fixed, specified by a noun like *everyone* as $\mathit{person}(x)$ or by a noun like *everything* as $\mathit{thing}(x)$, or given by the meaning of the quantified common noun (*people* or *person* in examples 20–21) and any modifiers it might have. In contrast, the scope of a quantifier — its second propositional argument — is chosen more freely, and semantic ambiguity can result from different scope choices. For example, although (22) is syntactically unambiguous, with a single c-structure and f-structure, it has two different meanings, depending on the order in which the quantifiers are applied. That is, the sentence is ambiguous because there is more than one way of putting its component meanings together.

(22) *Everyone heard something.*

Reading 1: For each person, there is a thing which that person heard (but each person may have heard a different thing).
$\mathit{every}(x, \mathit{person}(x), a(y, \mathit{thing}(y), \mathit{hear}(x, y)))$

Reading 2: There is something that everyone heard.
$a(y, \mathit{thing}(y), \mathit{every}(x, \mathit{person}(x), \mathit{hear}(x, y)))$

In Reading 1, we say that *everyone* has wide scope, and *something* has narrow scope. The scope relations are reversed in Reading 2, where *something* has wide scope and *everything* has narrow scope.

Similarly, as we discuss in detail in Chapter 15, Section 2.1, (23) is syntactically unambiguous, with only one c-structure tree and one f-structure. It is semantically ambiguous, however, since the scope of the quantifier can vary:

(23) *Someone seemed to yawn.*

Reading 1: It seemed that someone yawned (although there may not be anyone present).
$\mathit{seem}(a(x, \mathit{person}(x), \mathit{yawn}(x)))$

Reading 2: There is someone that seemed to yawn.
$a(x, \mathit{person}(x), \mathit{seem}(\mathit{yawn}(x)))$

According to Reading 1, the proposition $a(x, \mathit{person}(x), \mathit{yawn}(x))$ seems to hold, but the existence of the person (and therefore the occurrence of the yawn) is not certain — perhaps the only evidence was a noise. In contrast, Reading 2 claims that there is some individual x that satisfies the proposition $\mathit{person}(x)$ and that also seemed to yawn, satisfying the proposition $\mathit{seem}(\mathit{yawn}(x))$.

Such examples show that it is not adequate to rely solely on the f-structure as a representation of the meaning of a sentence; the single f-structure for (23) corresponds to more than one meaning. Our theory of semantics and the syntax-semantics interface allows us to deduce exactly these two meanings for (23), given its unambiguous syntactic structure.

This concludes our brief introduction to predicate logic. We have seen that predicate logic provides a basic yet expressive way of representing linguistic meaning. This is an advantage from our perspective, since much of our discussion focuses on issues in meaning assembly, and our claims about the meanings of particular constructions are fairly general.

4.2. Meaning Representations and Semantic Theories

In much LFG work on meaning and semantic composition, detailed assumptions about the nature and representation of linguistic meaning and its relation to syntactic structure have been explored, and a close analysis of the semantic contributions of particular phrases or constructions has been the main focus of concern. Work on integrating an LFG view of semantic composition with particular semantic theories is important and valuable, since this work not only allows for a fuller exploration of the relation of syntactic structure to meaning, but also makes important contributions to semantic theory.

Since the work of Montague (1970b), it has been common to use *intensional logic* to express linguistic meaning. Halvorsen (1983) proposes a theory of the association between f-structures and meanings, outlined briefly in Chapter 7, Section 4.1, which allows the construction of formulas of intensional logic to represent the meanings of utterances based on their f-structures. Meanings have also been represented as formulas of intensional logic in an LFG setting by Wedekind and Kaplan (1993).

In other work, the semantic theory of Situation Semantics (Barwise and Perry 1983) is assumed. Fenstad et al. (1987) propose that functional descriptions in rules and lexical entries describe not only the f-structure for an utterance but also a *Situation Schema*, which represents information that is relevant for semantic interpretation. Situation Semantics adheres to the *Relational Theory of Meaning*, whereby the meaning of an utterance is a relation between the situation in which an utterance is made — the *utterance situation* — and the situation described by the utterance, the *described situation*. Accordingly, the situation schemata proposed by Fenstad et al. (1987) represent a potentially underdetermined description of the relation between an utterance situation and a described situation. Fenstad et al. provide an extensive treatment of constraints on situation schemata as well as an algorithm for their interpretation. Gawron and Peters (1990) also propose a Situation-Theoretic view of anaphora, quantification, and their interactions from an LFG perspective, and their work includes an appendix containing an LFG grammar for the fragment of English that they treat.

Perhaps the most widely adopted theory of semantics among LFG researchers is Discourse Representation Theory (DRT: Kamp 1981; Kamp and Reyle 1993). Discourse Representation Theory assumes that each sentence in a discourse contributes to the construction of a *Discourse Representation Structure* (DRS) representing the discourse referents that are introduced as well as the conditions they must meet. Frey and Reyle (1983) advanced one of the first proposals for constructing Discourse Representation Structures for utterances based on their f-structures, and this work was continued by Wada and Asher (1986) and Asher and Wada (1988) in their proposals for LFG-based DRS construction. Muskens (1995) also proposes an analysis involving Underspecified Discourse Representation Structures (Reyle 1993) with syntactic assumptions that are very close to LFG.

As noted in Section 4, there is no obstacle to representing linguistic meanings according to any of these semantic theories within the glue approach. Dalrymple et al. (1997) discuss quantification and intensionality in the glue approach, using intensional logic to represent meanings. Van Genabith and Crouch (1999a) provide a detailed and very interesting discussion of different methods for incorporating dynamic and underspecified meaning representations, similar to the structures of Underspecified Discourse Representation Theory, within the glue approach (see also van Genabith and Crouch 1999b). Dalrymple et al. (1999b) briefly discuss the construction of Discourse Representation Structures in a glue setting, where meanings are given as expressions of Lambda DRT (Bos et al. 1994). DRT is also used in a glue setting by Haug (2008b), Bary and Haug (2011), Haug and Nikitina (2012) and Lowe (2012, 2015c) to model verbal tense and aspect and participial modification, by Flouraki and Kazana (2009) to model disjunctive agreement in Modern Greek, and by Arnold and Sadler (2012) to model affected experiencer constructions. In Part III of this book, we will use a version of DRT, Partial Compositional DRT (Haug 2014b), since it allows us to represent the semantics of anaphoric relations.

5. MEANING ASSEMBLY AND LOGICAL "GLUE"

This section introduces the glue theory of semantic composition and presents some basic examples of meaning assembly in the glue setting. We propose a logically based theory of semantic composition: instructions for combining meanings are stated as premises in a logical deduction. The deduction of the meaning of an utterance proceeds by combining these premises as the logic requires, which means that meaning composition need not proceed according to the rules of phrasal composition. This represents a move away from the phrase-structure based rule-to-rule hypothesis. In addition, the logic used to state constraints on meaning combination is a resource logic, *linear logic*, which treats meaning contributions as resources that are accounted for in the meaning deduction. Thus, the theory conforms to the desiderata introduced at the end of Section 3. The theory is often referred to as the *glue approach* because of the role of linear logic in stating how the meanings of the parts of an utterance can be "glued together" to form the meaning of the whole utterance.

5.1. Meaning Specifications and the Projection Architecture

The lexical entry for a proper name like *David* contains at least the syntactic information shown in (24):

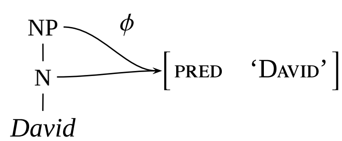
(24) *David* N ($\uparrow$ PRED) = 'DAVID'

We also assume the following simplified phrase structure rule for NP:

(25) $\text{NP} \longrightarrow \underset{\uparrow=\downarrow}{\text{N}}$

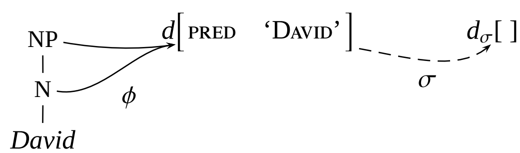
As discussed in Chapter 5, this lexical entry and phrase structure rule give rise to the syntactic structures in (26):

(26)



We now augment our theory with a *semantic structure* and its associated meaning. As described in Chapter 7, a linguistic structure like the semantic structure is related to other linguistic structures by means of *correspondence functions*. Here, the function σ relates f-structures to semantic structures, and we say that the semantic structure is a *projection* of the functional structure, related to the functional structure via the *σ (sigma) projection*. This is shown pictorially in (27), where d_σ is the semantic structure that is related to the f-structure labeled d by the correspondence function σ, represented as a dashed arrow:

(27)



As noted in Chapter 7, Section 1.1, there are two common and equivalent notations for the correspondence function:

(28) $d_\sigma \equiv \sigma(d)$

In the following, we use the more common subscript notation, rather than the parenthesis notation: that is, we write d_σ rather than $\sigma(d)$ for the semantic structure corresponding to d via the correspondence function σ. Nothing of substance depends on this notational choice; using the parenthesis notation would be equally correct.

We propose the augmented lexical entry in (29) for the proper name *David*. This lexical entry differs from the one in (24) in that the expression $\mathit{David} : {\uparrow}_\sigma$ has been added. No additions or changes to the phrase structure rule in (25) are necessary:

(29) *David* N $(\uparrow \text{PRED}) = \text{`D}\textsc{avid}\text{'}$
$\mathit{David} : {\uparrow}_\sigma$

The expression $\mathit{David} : {\uparrow}_\sigma$ is called a *meaning constructor*, since it is an expression that tells us how to construct meanings. In this simple case, there is no real meaning construction involved, since the meaning *David* is complete on its own. Other cases are more complex, as we will soon see.

Meaning constructors are pairs, with the left-hand side (the *meaning side*) representing a meaning and the right-hand side (the *glue side*) representing a logical formula over semantic structures corresponding to that meaning. The expression $\mathit{David} : {\uparrow}_\sigma$ says that *David* is the meaning associated with ${\uparrow}_\sigma$, the semantic projection of the f-structure $\uparrow$. In (27), the f-structure metavariable $\uparrow$ is instantiated to the f-structure labeled d, and so the meaning constructor pairs the meaning *David* with the semantic structure d_σ. Because meaning constructors associate meanings with semantic structures and not nodes of the c-structure tree, f-structural relations and not c-structure configurations are the primary determinant of how meanings combine.

As discussed in Section 4.1.3, meaning expressions are typed; the constant *David* is of type e. We assume that the basic types e and t are associated with semantic structures, since the type of an expression is important in determining how it can combine with other expressions. Types are written on the semantic structure as subscripts enclosed in angled brackets:

(30) $\mathit{David} : d_{\sigma\langle e\rangle}$

When the type of a semantic structure is clear from the context, we often omit it to reduce notational clutter.

For brevity, we can use a label like **[David]** to refer to the meaning constructor in (30). In (31), **[David]** is defined as a label representing the typed meaning constructor $\mathit{David} : d_{\sigma\langle e\rangle}$, in which d_σ is a semantic structure of type e and *David* is an individual constant representing the individual named David :

(31) **[David]** $\mathit{David} : d_{\sigma\langle e\rangle}$

Using names or labels for meaning constructors is useful for presenting deductions in a more compact form.

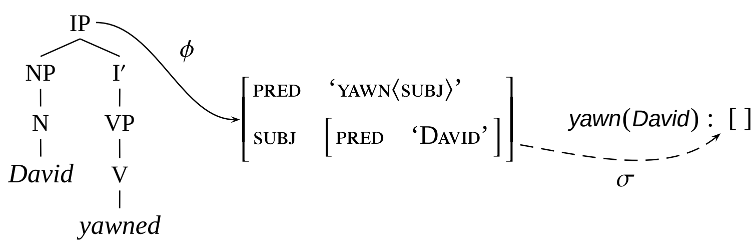
5.2. Assembling Meanings

Some words, such as verbs, must combine with other meanings to produce a complete meaning. For example, the meaning of an intransitive verb combines with the meaning of its subject to produce the meaning of its clause. This means that we must provide instructions for combining the meaning of a verb with its arguments to form the meaning of the clause as a whole. We provide these instructions in logical terms, the "glue language" of linear logic.

5.2.1. Example One: Intransitive Verbs

The syntactic structures for the sentence *David yawned*, together with the semantic result we desire, are:

(32) *David yawned.*



The semantic structure for the sentence is related to the f-structure for the sentence by the correspondence function σ, represented as a dashed arrow. We are not concerned with the internal makeup of the semantic structure here, and so we have represented it without internal attributes or values, as the structure [ ]. Below, we will see cases in which the semantic structure has attributes and values which play a crucial role in meaning deduction.

Let us see how the meaning *yawn*(*David*) for the sentence *David yawned* is obtained. We propose the following simplified lexical entry for the verb *yawned*:

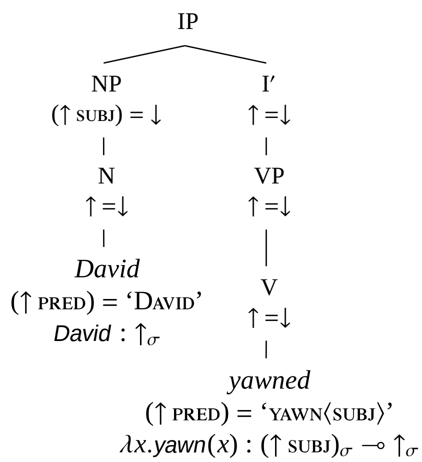
(33) *yawned* V $(\uparrow \textsc{pred}) = \text{‘}\textsc{yawn}\langle\textsc{subj}\rangle\text{’}$
$\lambda x.\mathit{yawn}(x) : (\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma$

The meaning constructor for *yawned* pairs the meaning for *yawned*, the one-place predicate $\lambda x.\mathit{yawn}(x)$, with the linear logic formula $(\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma$. This formula contains a new expression: the connective $\multimap$ is the *linear implication* symbol of linear logic, which we discuss in more detail in Section 7. For the moment, we can think of the symbol as expressing a meaning like *if. . . then. . .* : in this case, stating that *if* a semantic resource $(\uparrow \textsc{subj})_\sigma$ representing the meaning of the subject is available, *then* a semantic resource $\uparrow_\sigma$ representing the meaning of the sentence can be produced.

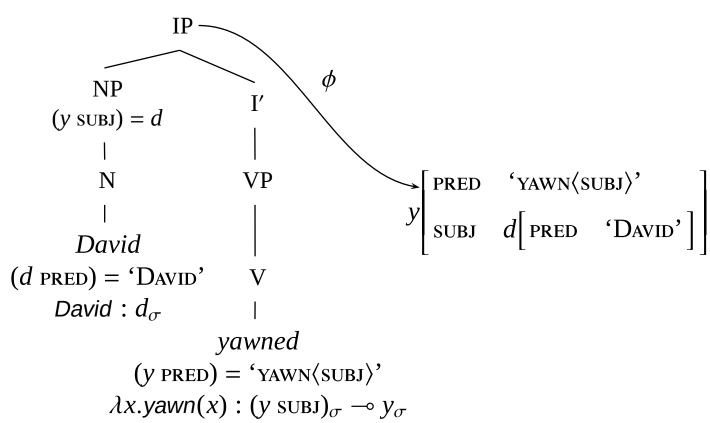
Additionally, the linear implication operator $\multimap$ carries with it a requirement for *consumption* and *production* of semantic resources: the formula $(\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma$ indicates that if a semantic resource $(\uparrow \textsc{subj})_\sigma$ is found, it is *consumed* and the semantic resource $\uparrow_\sigma$ is *produced*. We also assume that a name like *David* contributes a semantic resource, its semantic structure. In an example like *David yawned*, this resource is consumed by the verb *yawned*, which requires a resource for its SUBJ to produce a resource for the sentence. This accords with the intuition that the verb in a sentence must obtain a meaning for its arguments in order for a meaning for the sentence to be available. Thus, in the linear logic formulas that comprise the glue (right-hand) sides of meaning constructors, semantic structures are treated as resources that are contributed by the words and structures of the sentence.

In (34), we display the annotated c-structure for the sentence *David yawned*, together with the f-descriptions (including meaning constructors) contributed by the words *David* and *yawned*. In (35), we instantiate the metavariables represented by $\uparrow$ and $\downarrow$ in this tree, using the label y for the f-structure of the entire sentence and d for the f-structure of the SUBJ. Only the instantiated c-structure annotations that are important for our current discussion are displayed in (35).

(34) *David yawned.*



(35) *David yawned.*



The f-structure for *yawn* in (35) is labeled y, and the f-structure d for *David* is y's SUBJ. Since $(y\ \textsc{subj}) = d$, we can replace the expression $(y\ \textsc{subj})_\sigma$ by d_σ in the meaning constructors in (35), yielding the instantiated meaning constructors for *David* (labeled **[David]**) and *yawned* (labeled **[yawn]**):

(36) Meaning constructors for *David yawned*:

$$\begin{array}{lrcl} \textbf{[David]} & \mathit{David} & : & d_\sigma \\ \textbf{[yawn]} & \lambda x.\mathit{yawn}(x) & : & d_\sigma \multimap y_\sigma \end{array}$$

The meaning (left-hand) sides of the meaning constructors in (36) are familiar from our discussion of predicate logic formulas in Section 4.1 of this chapter. The meaning side of the meaning constructor labeled **[David]** is the proper noun meaning *David*, and the meaning side of the meaning constructor labeled **[yawn]** is the meaning of the intransitive verb *yawned*, the one-place predicate $\lambda x.\mathit{yawn}(x)$.

The glue (right-hand) sides of these meaning constructors indicate how these meanings are associated with the different parts of this sentence. The constant *David* is associated with the semantic structure d_σ. The glue side of the meaning constructor labeled **[yawn]** is more complex: as explained earlier, the connective $\multimap$ is the linear implication symbol of linear logic. In (36), we can think of this expression as encoding a meaning like *if* d_σ*, then* y_σ. In other words, the glue side of the meaning constructor labeled **[yawn]** in (36) states that if we consume a resource associated with the semantic structure d_σ, then we can produce a resource associated with the semantic structure y_σ.

We must also provide rules for how the glue side of each of the meaning constructors in (36) relates to the meaning side in a meaning deduction. For simple, nonimplicational meaning constructors like **[David]** in (36), the meaning on the left-hand side (*David*) is the meaning of the semantic structure on the right-hand side (d_σ). For implicational meaning constructors like **[yawn]**, which contain the linear implication operator $\multimap$, performing an inferential step on the glue side corresponds to applying a function to its argument on the meaning side:[3]

(37)
$$\frac{\begin{array}{rcl} x & : & f_\sigma \\ P & : & f_\sigma \multimap g_\sigma \end{array}}{P(x)\ :\ g_\sigma}$$

Each side of an implicational meaning constructor $P : f_\sigma \multimap g_\sigma$ requires a contribution: the glue side requires as its argument a semantic structure f_σ, and the meaning side requires an argument for the predicate P. When an appropriate resource such as $x : f_\sigma$ is available to provide the appropriate contributions on both the meaning and the glue sides, the result is a complete semantic resource on the glue side and its corresponding meaning on the meaning side. In the case at hand, the pairing of the linear logic formula $d_\sigma \multimap y_\sigma$ with the meaning term

[3]This is the standard correspondence as defined by the *Curry-Howard Isomorphism* relating propositions like $d_\sigma \multimap y_\sigma$ to terms like $\lambda x.\mathit{yawn}(x)$; see Crouch and van Genabith (2000) for more discussion.

$\lambda x.yawn(x)$ means that we apply the function $\lambda x.yawn(x)$ to the meaning *David* associated with d_σ, obtaining the meaning constructor $yawn(David) : y_\sigma$ for the sentence.

With these correspondences between linear logic formulas and meanings, we perform a series of reasoning steps like the following:

(38)

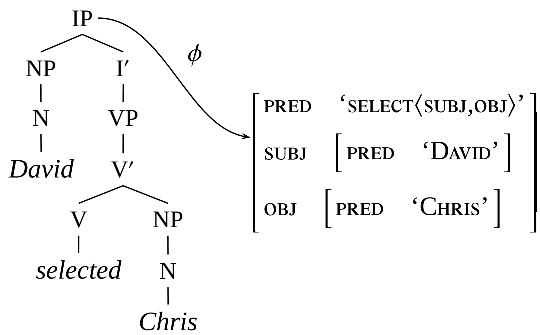
$David : d_\sigma$	This is the meaning constructor **[David]**. It associates the meaning *David* with the SUBJ semantic structure d_σ.
$\lambda x.yawn(x) : d_\sigma \multimap y_\sigma$	This is the meaning constructor **[yawned]**. On the glue side, if we find a semantic resource for the SUBJ d_σ, we consume that resource and produce a semantic resource for the full sentence y_σ. On the meaning side, we apply the function $\lambda x.yawn(x)$ to the meaning associated with d_σ.
$yawn(David) : y_\sigma$	By combining **[David]** and **[yawned]**, we have produced a semantic structure for the full sentence y_σ, associated with the meaning $yawn(David)$.

By using the rule in (37) and the meaning constructors **[David]** and **[yawned]**, we have deduced the meaning $yawn(David)$ for the sentence *David yawned*, as desired.

5.2.2. Example Two: Transitive Verbs

Our next example of meaning deduction involves a transitive verb; the example differs from the one just presented only in that the verb takes two arguments instead of one. The c-structure and f-structure for the sentence *David selected Chris* are:

(39) *David selected Chris.*



The lexical entry for the transitive verb *selected* is:

(40) *selected* V $(\uparrow \textsc{pred}) = \text{‘}\textsc{select}\langle\textsc{subj},\textsc{obj}\rangle\text{’}$
$\lambda x.\lambda y.\mathit{select}(x,y) : (\uparrow \textsc{subj})_\sigma \multimap [(\uparrow \textsc{obj})_\sigma \multimap \uparrow_\sigma]$

In the meaning constructor for the transitive verb *selected*, two arguments are required: a resource for the SUBJ, $(\uparrow \textsc{subj})_\sigma$, and a resource for the OBJ, $(\uparrow \textsc{obj})_\sigma$. The square brackets in this expression are there to make the groupings in the expression clear: *selected* requires a meaning for its SUBJ, then a meaning for its OBJ, to form a meaning for the sentence. In other words, this formula can be paraphrased as: “If we find a resource for the subject and a resource for the object, we can produce a resource for the entire sentence.” The meaning side is a function that requires two arguments and is applied to those arguments to produce a meaning for the sentence.

In (40), the glue side of the meaning constructor requires the verb to combine with its arguments in a particular order — the SUBJ first, then the OBJ — since this order must respect the order of combination of meanings specified in the lambda expression on the meaning side. Importantly, the meaning constructor shown in (41) is exactly equivalent to the one in (40) except that the order of argument combination on both the meaning and glue sides is reversed, so that the verb combines with its OBJ first and then its SUBJ:

(41) $\lambda y.\lambda x.\mathit{select}(x,y) : (\uparrow \textsc{obj})_\sigma \multimap [(\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma]$

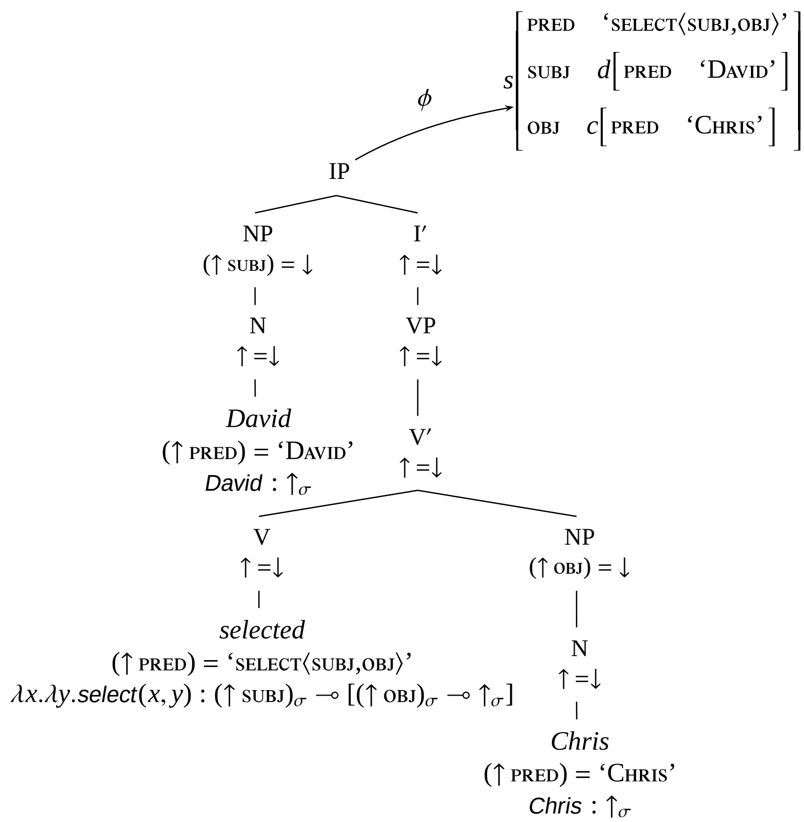
In formal terms, the glue side of this meaning constructor is *logically equivalent* to the glue side of the meaning constructor in (40). In principle, we can choose any order of combination of premises, with no theoretical significance attached to the choice we make.

The lexical entry for *Chris* is analogous to the one for *David*, providing a meaning constructor with the meaning *Chris*:

(42) *Chris* N $(\uparrow \textsc{pred}) = \text{‘Chris’}$
$\mathit{Chris} : \uparrow_\sigma$

With these lexical entries for the words in the sentence, we have the following structures:

(43) *David selected Chris.*



Instantiating the $\uparrow$ and $\downarrow$ metavariables appropriately, we have the following meaning constructors, labeled **[David]**, **[Chris]**, and **[select]**:

(44) Meaning constructor premises for *David selected Chris*:

[David]	$David$	$: \; d_\sigma$
[Chris]	$Chris$	$: \; c_\sigma$
[select]	$\lambda x.\lambda y.select(x, y)$	$: \; d_\sigma \multimap [c_\sigma \multimap s_\sigma]$

From these premises, we can make the following logical deduction:

(45) $\mathit{David} : d_\sigma$ — This is the meaning constructor **[David]**. It associates the subject semantic structure d_σ with the meaning *David*.

$\mathit{Chris} : c_\sigma$ — This is the meaning constructor **[Chris]**. It associates the object semantic structure c_σ with the meaning *Chris*.

$\lambda x.\lambda y.\mathit{select}(x, y) : d_\sigma \multimap [c_\sigma \multimap s_\sigma]$

This is the meaning constructor **[select]**. On the glue side, if semantic resources for the subject d_σ and the object c_σ are found, a resource for the sentence can be produced. On the meaning side, the two-place predicate *select* is applied to the subject meaning x and then the object meaning y to produce the meaning $\mathit{select}(x, y)$ for the sentence.

$\mathit{select}(\mathit{David}, \mathit{Chris}) : s_\sigma$ — We have produced a semantic structure s_σ for the full sentence, associated with the meaning $\mathit{select}(\mathit{David},\mathit{Chris})$.

As desired, we have concluded that the meaning for the sentence *David selected Chris* is $\mathit{select}(\mathit{David}, \mathit{Chris})$.

In this book, we will present glue derivations in this informal way. Much glue literature uses a more standard proof format, as in (46), which represents the same proof as was presented informally in (45):

(46)
$$\dfrac{\dfrac{\mathit{David} : d_\sigma \quad \lambda x.\lambda y.\mathit{select}(x, y) : d_\sigma \multimap [c_\sigma \multimap s_\sigma]}{\lambda y.\mathit{select}(\mathit{David}, y) : c_\sigma \multimap s_\sigma} \quad \mathit{Chris} : c_\sigma}{\mathit{select}(\mathit{David}, \mathit{Chris}) : s_\sigma}$$

See Asudeh (2012, Chapter 4) for an accessible overview discussion of glue proofs, and the papers in Dalrymple (1999) for additional discussion.

We sometimes take advantage of the possibility of referring to a meaning constructor by a label to present an abbreviated representation of a derivation from a set of premises. For example, we can abbreviate the derivation outlined in (46) in the following way:

(47)

[David]	David	:	d_σ
[Chris]	Chris	:	c_σ
[select]	$\lambda x.\lambda y.\mathit{select}(x, y)$	:	$d_\sigma \multimap [c_\sigma \multimap s_\sigma]$

[David], **[Chris]**, **[select]** $\vdash \mathit{select}(\mathit{David}, \mathit{Chris}) : s_\sigma$

The final line in (47) represents the derivation of the meaning $\mathit{select}(\mathit{David}, \mathit{Chris})$ for the semantic structure s_σ from the premises labeled **[David]**, **[Chris]**, and **[select]**. It contains a new expression $\vdash$, sometimes called the *turnstile*, which indicates that the conclusion on the right is derivable from the premises on the left. Thus, the final line in (47) means that the conclusion $\mathit{select}(\mathit{David}, \mathit{Chris}) : s_\sigma$ is derivable from the premises labeled **[David]**, **[Chris]**, and **[select]**.

In sum, we have used linear logic as a *glue language* to provide instructions on how to glue together or assemble meanings. The use of this logical language lets us express constraints on meaning combination in a formally coherent and flexible way, taking advantage of the syntactic relations imposed by the f-structure.

6. CONSTRUCTIONAL MEANING

In the examples just presented, meaning terms are associated with words and not phrase structure rules. In a language like English, annotations on phrase structure rules serve mainly to determine the functional syntactic roles of constituents. For the most part, phrase structure rules play only this syntactic organizing function and do not contribute meaning on their own. This is true for many other languages as well.

However, this generalization is not exceptionless. There are cases in which a meaning is associated with a phrasal construction as a whole, where the semantic properties of the construction go beyond the semantic properties of the words it contains. A particularly clear example of meaning associated with phrasal configuration is provided by relative clauses with no relative pronoun, such as:

(48) *the man I met*

In this example, the phrase *I met* is a relative clause modifier of *man*. This information is not associated with either the word *I* or the word *met*. Instead, the interpretation of *I met* as a relative clause is due to the phrasal configuration in which it appears. In Chapter 17, we will propose an analysis of the semantics of relative clauses, and we will see that the phrase structure rule associated with relative clause formation in English can be annotated with a meaning constructor, and thus can make a contribution to meaning.

The view that meanings can be attached either to lexical items or to c-structure configurations accords with the views of Kaplan and Bresnan (1982, fn. 2), but not with some other proposals. In particular, Halvorsen (1983) proposes that semantic content is introduced only in the lexicon, by words and not phrase structure rules (see also Bresnan 1982a). In a very interesting discussion of verbless sentences, including the topic-comment construction in Vietnamese and nominal sentences with no copula in Maori (discussed in Chapter 5, Section 4.5), Rosén (1996) shows that attempts to restrict semantic content to appearing only in the lexicon are inadvisable. Phrase structure configurations can be associated with meaning constructors, and these constructors can make an essential contribution to meaning deduction.

7. THE "GLUE" LANGUAGE: LINEAR LOGIC

We use expressions of *linear logic* (Girard 1987) to encode instructions on how to assemble meanings. Here, we informally describe the properties of the small fragment of linear logic (the *multiplicative fragment*) that we will use.[4]

Intuitively, linear logic is different from classical logic in that premises in a linear logic deduction are treated as resources that must be kept track of; that is, as occurrences of resources that can be introduced or consumed. In contrast, premises in a deduction in classical logic are statements about what is or is not true.

To illustrate this difference, let us assume that we can deduce the statement *You will get wet* from the premises *If it is raining outside, you will get wet* and *It is raining outside* in classical logic:

(49) Classical logic:
If it is raining outside, you will get wet.
It is raining outside.
____
You will get wet.

In classical logic, if a conclusion can be deduced from a set of premises, the same conclusion can still be deduced if additional premises are added:

(50) Classical logic:
If it is raining outside, you will get wet.
It often rains in March.
It was raining yesterday.
It is raining outside.
____
You will get wet.

In contrast, linear logic does not necessarily allow the same conclusion to be deduced when additional premises are introduced. Instead, propositions in linear logic can be thought of as resources, and an economic metaphor is sometimes used.

For instance, we can use the symbol \$1 for the proposition that you have a dollar, $\$1 \multimap \mathit{apple}$ for the linear logic proposition that if you have \$1, you can have an apple, and *apple* for the proposition that you can have an apple. The following is valid in linear logic:

(51) $[\$1 \multimap \mathit{apple}],\ \$1 \vdash \mathit{apple}$

[4] In this section, we describe only the properties of the linear implication operator $\multimap$. Proof rules for our fragment of linear logic are given in the appendix to the chapter (page 342).

This can be read as:

(52) *If you have* \$1*, you can have an apple.*
You have \$1.
$\overline{}$
You can have an apple.

Just as in the real world, it is not possible to get two apples with \$1, or to still have \$1 as well as the apple:

(53) INCORRECT (obtaining two apples with \$1):

$$[\$1 \multimap \textit{apple}], \$1 \vdash \textit{apple}, \ \textit{apple}$$

INCORRECT (obtaining an apple while keeping \$1):

$$\$1, [\$1 \multimap \textit{apple}] \vdash \$1, \textit{apple}$$

More schematically, inferences in linear logic work in the following way:

(54) INCORRECT: $A \vdash A, A$
We cannot deduce A, A from A.
A resource cannot be duplicated.

INCORRECT: $A, B \vdash A$
We cannot deduce A from A, B.
A resource cannot be discarded.

INCORRECT: $A, [A \multimap B] \vdash A, B$
The resource A is consumed by $A \multimap B$ to conclude B.
A resource is consumed by an implication.

INCORRECT: $A, [A \multimap B] \vdash A \multimap B, B$
Both A and $A \multimap B$ are consumed in concluding B.
A linear implication is also a resource and is consumed in the deduction.

CORRECT: $A, [A \multimap B] \vdash B$

This resource-sensitivity of linear logic allows us to model the meaning contributions of words as *semantic resources* that must be accounted for. The meaning of a sentence is deduced from the meanings of its component parts; it would be incorrect to deduce the same meaning for the sentence if words or phrases are added or subtracted. Each word or phrase makes a unique contribution that must be reflected in the final meaning of the sentence, and meanings cannot be arbitrarily duplicated, added, or discarded.

7.1. Semantic Completeness and Coherence

Formally, we say that a meaning derivation for an utterance is *semantically complete* if the meaning derivation from the premises contributed by the meaning-bearing items in the sentence produces a meaning for the semantic structure for the utterance that does not contain any unsaturated expressions (that is, in which all of the meaning contribution requirements are satisfied). If no such meaning can be produced, some required material is missing and the utterance is *semantically incomplete*.

We say that a meaning derivation for an utterance is *semantically coherent* if the meaning derivation produces a meaning for the utterance with no additional unused premises remaining. If extra resources remain, the utterance is *semantically incoherent*.

Semantic completeness and coherence are related in a clear way to the syntactic Completeness and Coherence conditions on f-structures discussed in Chapter 2, Section 4.6. This is as expected, since most syntactic arguments also make a semantic contribution and thus must be accounted for in a meaning derivation; indeed, our logically defined semantic completeness and coherence conditions subsume syntactic Completeness and Coherence in all cases except for pleonastic or semantically empty (expletive) arguments, which make no semantic contribution and are not accounted for in a semantic derivation. The following sentence is syntactically and semantically incomplete:

(55) **Yawned.*

The sentence is syntactically incomplete because the verb *yawned* requires a SUBJ, and no subject is present; the sentence is semantically incomplete because the meaning constructor for *yawned* requires a semantic resource corresponding to its subject, but none can be found. Example (56) is both syntactically and semantically incoherent:

(56) **David yawned Chris.*

This example is syntactically incoherent due to the presence of an OBJ argument, which *yawned* does not require. It is semantically incoherent because the meaning constructor for *yawned* requires only a SUBJ resource, and in a meaning deduction from these premises the semantic resource for the OBJ *Chris* remains unused.

Semantic and syntactic completeness differ for arguments that make no semantic contribution:

(57) **Rained.*

The verb *rained* requires a SUBJ, but there is no SUBJ in (57); therefore, the sentence is syntactically incomplete. The semantic completeness condition is not violated, however, because the SUBJ of *rained* is not required to make a semantic contribution — an expletive subject is syntactically required, but not semantically necessary.[5]

Another difference between syntactic and semantic coherence involves modifying adjuncts: a semantic deduction in which the meaning contribution of a modifier is not incorporated is semantically incoherent, since all meanings must

[5]This is indicated by the appearance of the SUBJ argument outside the angled brackets in the semantic form for *rain*, as shown in (102) of Chapter 2, Section 4.6.1.

be taken into account. That is, the semantic coherence condition prevents us from assigning an unmodified meaning to a sentence with a modifier:

(58) *David ran quickly*.

cannot mean: *run*(*David*)

The modifier *quickly* is not constrained by the syntactic Completeness and Coherence conditions, which apply only to governable grammatical functions. Semantically, however, its meaning contribution must be taken into account, and the deduction is semantically incoherent if the modifier meaning does not appear.

7.2. Glue Deductions and Categorial Grammar

Glue semantic deductions have an interesting property: as shown by Dalrymple et al. (1999a), whether or not a glue deduction is possible depends only on the linear logic glue formulas on the right-hand side of the meaning constructor, never on the meanings involved in the deduction. This means that we can think of the meaning deduction process purely in terms of the linear logic deduction; on the basis of the resulting deduction, we can determine the corresponding meaning by function abstraction and application.

For example, we can present deductions in an abbreviated form like (59), which is the same as the deduction in (38) on page 311 except that meaning terms have been omitted. On the basis of this deduction, we can determine the meaning corresponding to the semantic structure y_σ by function application, following the function application rule presented in (37).

(59)

	d_σ	The SUBJ semantic structure d_σ is present.
	$d_\sigma \multimap y_\sigma$	If we find a resource for the SUBJ semantic structure d_σ, we can produce a resource for the semantic structure for the full sentence y_σ.
	y_σ	We have produced a semantic structure for the full sentence y_σ.

In fact, as discussed by Dalrymple et al. (1999a), this aspect of glue semantic deductions is strongly similar to Categorial Grammar (Oehrle et al. 1988; Moortgat 1988, 1996; Morrill 1994, 2015, 2011; Steedman 1996, 2001; Moot and Retore 2012). Linguistic analysis in Categorial Grammar is a deductive process, in which the syntactic structure and the meaning of a sentence are obtained by a logical deduction from premises contributed by its words. The Lambek calculus (Lambek 1958), the logical system commonly used in syntactic analysis in categorial frameworks, is actually a fragment of *noncommutative multiplicative linear logic* and so is very close to the linear logic glue language.

Probably the most important difference between the categorial approach and the glue approach is in the syntactic primitives that are relevant for semantic composition. In Categorial Grammar, a predicate combines with its arguments on the basis of relations defined on the surface string, like to-the-left-of and to-the-right-of; in the glue approach, in contrast, semantic deductions are guided by f-structural relations like SUBJ, OBJ, and ADJ. This frees the glue approach from concerns with crosslinguistically variable word order relations and allows semantic composition to proceed according to the more abstract syntactic organization of f-structure.

8. QUANTIFICATION

Here we briefly outline our theory of quantification and the treatment of generalized quantifiers, since an explicit theory of the syntax and semantics of noun phrases will be important in subsequent discussion, particularly in relation to adjectival modification and relative clauses. For a full explication of the theory of quantification presented in this section, see Dalrymple et al. (1997).

8.1. Quantifier Scope

As discussed in Section 4.1.4 of this chapter, the meaning of a sentence like *Everyone yawned* is:

(60) *Everyone yawned.*

$\mathit{every}(x, \mathit{person}(x), \mathit{yawn}(x))$

Here, *every* relates an arbitrary individual represented by x to two propositions about that individual, $\mathit{person}(x)$ and $\mathit{yawn}(x)$. We propose the lexical entry in (61) for the quantificational pronoun *everyone*:

(61) *everyone* N $(\uparrow \text{PRED}) = \text{`EVERYONE'}$
$\lambda S.\mathit{every}(x, \mathit{person}(x), S(x)) : \forall H.[\uparrow_\sigma \multimap H] \multimap H$

This entry has a number of new features, which we will now explain.

8.1.1. Quantifier Scope and Meaning Assembly

The glue side of the meaning constructor in the second line of the lexical entry in (61) has several new aspects, different from the meaning constructors for proper names and verbs that we have examined thus far:

(62) $\forall H.[\uparrow_\sigma \multimap H] \multimap H$

First, a universal quantifier $\forall$ binds the variable H, which ranges over semantic structures that correspond to possible scopes of the quantifier. The universal quantifier $\forall$ means something close to the English word *all* or *every*, and it binds the variable that follows it; see Partee et al. (1993, Chapter 7) for a full explanation. In (62), the expression $[\uparrow_\sigma \multimap H] \multimap H$ is asserted to be valid for any H: if an implicational resource $\uparrow_\sigma \multimap H$ is provided for any H, we can consume the implicational resource and obtain the resource H.

The second new aspect of the meaning constructor in (61) is that it contains an *embedded implication*: the implication $\uparrow_\sigma \multimap H$ appears on the left side of the main linear implication operator. We can think of the expression $\uparrow_\sigma \multimap H$ as the *argument* required by the meaning constructor for *everyone*. As we have seen, the arguments required by a meaning constructor appear on the left side of the main implication operator. An intransitive verb like *yawned* requires as its argument the meaning of its subject, $(\uparrow \textsc{subj})_\sigma$:

(63) $\lambda z.\mathit{yawn}(z) : (\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma$

In contrast, the quantificational pronoun *everyone* takes a more complex argument, an implicational meaning constructor $\uparrow_\sigma \multimap H$, in the lexical entry in (61). That is, *everyone* requires as its argument a meaning constructor that consumes a resource for $\uparrow_\sigma$ to produce some semantic structure H. An intransitive verb with the quantificational pronoun *everyone* as its subject would provide such a meaning, since it consumes a meaning for $\uparrow_\sigma$, the semantic structure for *everyone*, to produce another semantic resource which we can call H. Any other meaning constructor that consumes a meaning for $\uparrow_\sigma$ to produce another semantic structure H will also fill the bill.

As Saraswat (1999) notes, another way to think of the embedded implication in (61) is that the quantifier must perform a test on its environment to determine whether some implicational resource can be found which matches the required resource $\uparrow_\sigma \multimap H$. To perform this test, the quantifier proposes the resource $\uparrow_\sigma$. If a resource H can then be obtained for some semantic structure H, the requirements of the quantifier are satisfied, and the conclusion H is valid.

8.1.2. Quantifier Scope Meaning

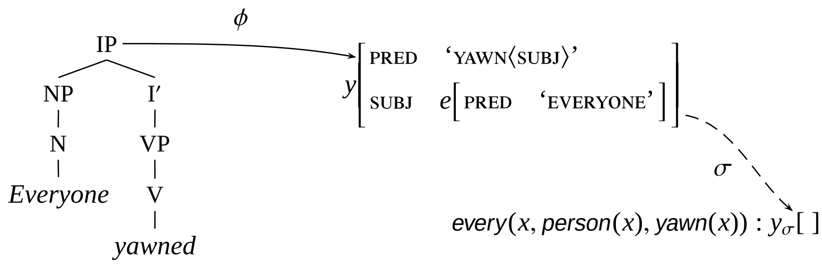
The meaning (left-hand) side of the lexical entry for *everyone* in (61) is:

(64) $\lambda S.\mathit{every}(x, \mathit{person}(x), S(x))$

In this expression, $S(x)$ represents possible meanings for the scope of the quantifier.

To take a concrete example, we present the c-structure, f-structure, and meaning constructors for the sentence *Everyone yawned* in (65); we have also filled in the target meaning for the sentence, associated with the semantic structure y_σ:

(65) *Everyone yawned.*



[everyone] $\lambda S.\mathit{every}(x, \mathit{person}(x), S(x)) \;:\; \forall H.[e_\sigma \multimap H] \multimap H$

[yawn] $\lambda z.\mathit{yawn}(z) \;:\; e_\sigma \multimap y_\sigma$

The right-hand side of the meaning constructor labeled **[everyone]** requires as its argument a meaning constructor of the form:

(66) $e_\sigma \multimap H$

The glue side of the meaning constructor labeled **[yawn]** is of exactly this form, and the derivation is successful if the variable H for the scope semantic structure is instantiated to y_σ. Following the discussion in Section 7.2, we perform the glue deduction shown in (67), displaying only the glue sides of the meaning constructors.

(67)

$\forall H.[e_\sigma \multimap H] \multimap H$	If we are given a resource $e_\sigma \multimap H$ for some semantic structure H, we can produce a resource for H.
$e_\sigma \multimap y_\sigma$	H can be instantiated as y_σ, satisfying the requirement in the previous step.
y_σ	We have produced a resource y_σ for the full sentence.

To determine the meaning that results from combining the meaning constructors labeled **[everyone]** and **[yawn]** according to the glue deduction in (67), we follow the function application rule presented in (37) on page 310, applying the meaning of the quantificational pronoun $\lambda S.\mathit{every}(x, \mathit{person}(x), S(x))$ to its argument $\lambda z.\mathit{yawn}(z)$. The resulting meaning expression is:

(68) $\mathit{every}(x, \mathit{person}(x), [\lambda z.\mathit{yawn}(z)](x))$

or, equivalently:

(69) $\mathit{every}(x, \mathit{person}(x), \mathit{yawn}(x))$

In sum, assuming the meaning constructors shown in (65) for *everyone* and *yawned*, we can perform the following full glue deduction:

(70) $\lambda S.every(x, person(x), S(x)) : \forall H.[e_\sigma \multimap H] \multimap H$

This is the meaning constructor **[everyone]**. On the glue side, if we are given a resource $e_\sigma \multimap H$ for some semantic structure H, we can produce a resource for H. On the meaning side, we apply the predicate $\lambda S.every(x, person(x), S(x))$ to the meaning corresponding to the resource $e_\sigma \multimap H$.

$\lambda z.yawn(z) : e_\sigma \multimap y_\sigma$

This is the meaning constructor **[yawn]**. If we are given a resource e_σ corresponding to the SUBJ, we can produce a resource y_σ for the entire sentence. The meaning corresponding to this expression is $\lambda z.yawn(z)$.

$every(x, person(x), yawn(x)) : y_\sigma$

We have produced a resource y_σ for the full sentence, corresponding to the meaning $every(x, person(x), yawn(x))$, by assuming that H is the semantic structure y_σ.

We conclude that the sentence has the meaning $every(x, person(x), yawn(x))$, as desired.

8.1.3. Determination of Scope Semantic Structure

Example (70) shows that the variable H in the semantic constructor for the quantificational pronoun *everyone* can be instantiated to the semantic structure y_σ. In Section 4.1.4, we saw that the scope of a quantifier is not syntactically fixed: sentences containing quantificational words may exhibit quantifier scope ambiguity. What are the possible semantic structures that can be chosen as the scope of a quantifier?

First, we note that the semantic structure that is chosen as the scope of a quantifier need not correspond to any f-structure constituent. For example, it has long been noted that the restriction of a quantifier can serve as the scope of another quantifier (Dalrymple et al. 1997):

(71) *Every relative of a student attended.*

One reading of this sentence is paraphrasable as *Everyone who is a relative of some student attended*:

(72) $every(x, a(y, student(y), relative.of(x, y)), attend(x))$

An abbreviated f-structure for this sentence is:

(73) *Every relative of a student attended.*

$$\left[\begin{array}{ll} \text{PRED} & \text{`ATTEND}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll} \text{SPEC} & \left[\begin{array}{ll} \text{PRED} & \text{`EVERY'} \end{array}\right] \\ \text{PRED} & \text{`RELATIVE}\langle\text{OBL}_{\text{OF}}\rangle\text{'} \\ \text{OBL}_{\text{OF}} & \left[\begin{array}{ll} \text{DEF} & - \\ \text{PRED} & \text{`STUDENT'} \end{array}\right] \end{array}\right] \end{array}\right]$$

Treating the article *a* as a quantificational determiner, we see that its scope is $\mathit{relative.of}(x, y)$, the proposition that y is a relative of x. This meaning corresponds roughly to the subphrase *relative of*, but does not correspond to an f-structure constituent. Instead, the more fine-grained semantic structure is the appropriate level to define quantifier scoping possibilities; this will become clear in our discussion of the meanings of determiners and common noun phrases in Section 8.2.

Second, we require the scope of the quantifier to contain the variable bound by the quantifier. That is, the scope of the quantifier must be a function of the argument position in which the predicate appears. As noted by Dalrymple et al. (1997), this follows without stipulation from our logical system: the embedded implication that the quantifier requires to determine its scope meaning is an implication from the meaning of the quantified noun phrase to the scope meaning.

A number of other constraints on quantifier scoping have been proposed: quantifiers may be required to find their scope inside some syntactically definable domain, or to scope either inside or outside another quantifier. Since our focus here is not on a complete theory of quantification, we will not discuss constraints like these or show how they can be incorporated into the framework we propose. For detailed discussion of quantifier scoping constraints and a proposal for how they can be imposed in a glue setting, see Crouch and van Genabith (1999).

8.1.4. Abstraction

The rule for function application given in (37) has been important in the examples we have seen so far. In order to handle sentences with multiple quantifiers, we also require a rule of abstraction that allows a hypothetical resource to be proposed in order to create a function. The rule in (74) allows us to temporarily posit an additional premise in the deduction, a semantic resource f_σ associated with the meaning x. A semantic resource hypothesized in this way is notationally distinguished from other premises in that it is enclosed in square brackets: $[f_\sigma]$. If we can successfully perform a deduction (represented by elliptical dots $\vdots$) from this and other meaning constructor premises, producing a semantic resource g_σ with meaning P as in (74), we can *discharge* the assumption $x : [f_\sigma]$, and we are left with the meaning constructor $\lambda x.P(x) : f_\sigma \multimap g_\sigma$.

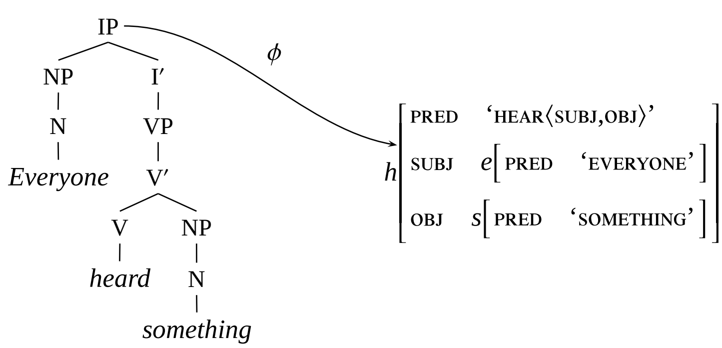
(74)
$$\dfrac{\begin{array}{rcl} x & : & [f_\sigma] \\ & \vdots & \\ P(x) & : & g_\sigma \end{array}}{\lambda x.P(x) \ : \ f_\sigma \multimap g_\sigma}$$

Intuitively, we have shown that if we are given a resource f_σ, we can obtain g_σ, exactly the import of the linear logic expression $f_\sigma \multimap g_\sigma$. On the meaning side, we have shown that by providing x, we can produce the meaning $P(x)$ — in other words, that we have proven the existence of a function $\lambda x.P(x)$. This abstraction rule will be helpful in the treatment of quantifier scope ambiguity as well as in future discussion. The appendix to this chapter (page 342) contains the full set of rules of deduction for our fragment of linear logic.

8.1.5. Quantifier Scope Ambiguity

By allowing different choices for the scope of quantifiers, and different orders in which multiple quantifiers scoping at the same point can apply, we can produce multiple meanings for a sentence with multiple quantifiers. As noted in Section 4.1.4 in our discussion of (22), the sentence *Everyone heard something* is syntactically unambiguous but has two different meanings, depending on the order in which the quantifiers are applied. This sentence has the c-structure, f-structure, and meaning constructors in (75):

(75) *Everyone heard something.*



[everyone]	$\lambda S.\mathit{every}(x, \mathit{person}(x), S(x))$	:	$\forall H.[e_\sigma \multimap H] \multimap H$
[something]	$\lambda S.\mathit{a}(y, \mathit{thing}(y), S(y))$	:	$\forall H.[s_\sigma \multimap H] \multimap H$
[hear]	$\lambda z.\lambda w.\mathit{hear}(w, z)$	:	$s_\sigma \multimap [e_\sigma \multimap h_\sigma]$

The meaning constructors for the quantifiers **[everyone]** and **[something]** each require an implicational meaning constructor of the general form $F_\sigma \multimap H$. They differ in that the meaning constructor **[everyone]** refers to the subject semantic structure, e_σ, while the meaning constructor **[something]** refers to the object semantic structure, s_σ.

The meaning constructor **[hear]** is not exactly of this form, since it requires two resources to produce a meaning for the clause: a resource corresponding to the subject meaning e_σ, and a resource corresponding to the object meaning s_σ. In fact, we can obtain a meaning constructor of the form that **[everyone]** requires as its argument by using the abstraction rule given in (74), supplying a hypothetical resource $v : [s_\sigma]$ to **[hear]**. We can then combine **[hear]** with **[everyone]** under the hypothesized resource, discharge the $v : [s_\sigma]$ assumption, and combine the resulting meaning constructor with **[something]**. The deduction is shown in (76).

(76) $\lambda z.\lambda w.\mathit{hear}(w,z) : s_\sigma \multimap [e_\sigma \multimap h_\sigma]$

This is the meaning constructor **[hear]**. On the glue side, if we are given a resource s_σ corresponding to the OBJ, we can produce an implicational resource $e_\sigma \multimap h_\sigma$. On the meaning side, we require a meaning z for the OBJ to produce the meaning $\lambda w.\mathit{hear}(z,w)$.

$v : [s_\sigma]$

We hypothetically assume the existence of a resource s_σ with meaning v.

$\lambda w.\mathit{hear}(w,v) : [e_\sigma \multimap h_\sigma]$

Taking into account the hypothesized resource in the previous step, we have satisfied the requirement for a resource s_σ, and we obtain the implicational resource $e_\sigma \multimap h_\sigma$. On the meaning side, we apply $\lambda z.\lambda w.\mathit{hear}(w,z)$ to the hypothesized meaning v, obtaining $\lambda w.\mathit{hear}(w,v)$.

$\lambda S.\mathit{every}(x,\mathit{person}(x),S(x)) : \forall H.[e_\sigma \multimap H] \multimap H$

This is the meaning constructor **[everyone]**. On the glue side, it requires an implicational meaning constructor of the form $e_\sigma \multimap H$. In the previous step, we produced a meaning constructor that is of a suitable type, and we can combine the two, instantiating H to h_σ.

$\mathit{every}(x,\mathit{person}(x),\mathit{hear}(x,v)) : h_\sigma$

On the glue side, we have now obtained a resource h_σ. On the meaning side, we obtain the meaning associated with h_σ by applying $\lambda S.\mathit{every}(x,\mathit{person}(x),S(x))$ to $\lambda w.\mathit{hear}(w,v)$.

$\lambda v.\mathit{every}(x,\mathit{person}(x),\mathit{hear}(x,v)) : s_\sigma \multimap h_\sigma$

We now discharge the s_σ assumption introduced in the second step, producing an implication on the glue side, $s_\sigma \multimap h_\sigma$. On the meaning side, we abstract out the meaning v. We now have a meaning constructor of the appropriate form to combine with **[something]**.

$\lambda S.a(y, thing(y), S(y)) : \forall H.[s_\sigma \multimap H] \multimap H$

This is the meaning constructor **[something]**. On the glue side, it requires an implicational meaning constructor of the form $s_\sigma \multimap H$. We have a meaning constructor that is of a suitable type, and we again instantiate H to h_σ.

$a(y, thing(y), every(x, person(x), hear(x, y))) : h_\sigma$

On the glue side, we have obtained a resource h_σ. On the meaning side, we obtain the final meaning by applying $\lambda S.a(y, thing(y), S(y))$ to $\lambda v.every(x, person(x), hear(x, v))$.

This deduction results in the reading for this sentence in which the object *something* has wide scope: there is a particular thing which everyone heard. The other meaning, where *something* has narrow scope, proceeds similarly. Here we take advantage of the observation made in Section 5.2.2 that a predicate may combine with its arguments in any order; in particular, a transitive verb may combine with its subject first and then its object, or the object first and then the subject. In formal terms, the two meaning constructors in (77) are logically equivalent; note that the lambda-bound variables z and w as well as the semantic structures s_σ and e_σ appear in different orders in (77a) and (77b).

(77) a. $\lambda z.\lambda w.hear(w, z) : s_\sigma \multimap [e_\sigma \multimap h_\sigma]$

b. $\lambda w.\lambda z.hear(w, z) : e_\sigma \multimap [s_\sigma \multimap h_\sigma]$

Thus, we begin the deduction of the narrow-scope reading of *something* with the logically equivalent version of the meaning constructor **[hear]** in (77b).

(78) $\lambda w.\lambda z.\mathit{hear}(w,z) : e_\sigma \multimap [s_\sigma \multimap h_\sigma]$

This meaning constructor is a variant version of **[hear]**, requiring a resource e_σ corresponding to the SUBJ to produce an implicational resource $s_\sigma \multimap h_\sigma$.

$v : [e_\sigma]$

We hypothetically assume the existence of a resource e_σ with meaning v.

$\lambda z.\mathit{hear}(v,z) : [s_\sigma \multimap h_\sigma]$

As above, the hypothesized resource satisfies the requirement for a resource e_σ.

$\lambda S.\mathit{a}(y,\mathit{thing}(y),S(y)) : \forall H.[s_\sigma \multimap H] \multimap H$

This is the meaning constructor **[something]**. It requires an argument of the form produced in the previous step of the deduction.

$\mathit{a}(y,\mathit{thing}(y),\mathit{hear}(v,y)) : h_\sigma$

Combining the resources in the previous two steps, we have obtained a resource h_σ, still under the hypothesized meaning v associated with e_σ.

$\lambda v.\mathit{a}(y,\mathit{thing}(y),\mathit{hear}(v,y)) : e_\sigma \multimap h_\sigma$

We now discharge the assumption introduced in the second step, and we have a meaning constructor of the appropriate form to combine with **[everyone]**.

$\lambda S.\mathit{every}(x,\mathit{person}(x),S(x)) : \forall H.[e_\sigma \multimap H] \multimap H$

This is the meaning constructor **[everyone]**. We combine it with the meaning constructor created in the previous step, instantiating H to h_σ.

$\mathit{every}(x,\mathit{person}(x),\mathit{a}(y,\mathit{thing}(y),\mathit{hear}(x,y))) : h_\sigma$

On the glue side, we have obtained a resource h_σ. On the meaning side, we obtain the final meaning by applying $\lambda S.\mathit{every}(x,\mathit{person}(x),S(x))$ to $\lambda v.\mathit{a}(y,\mathit{thing}(y),\mathit{hear}(v,y))$.

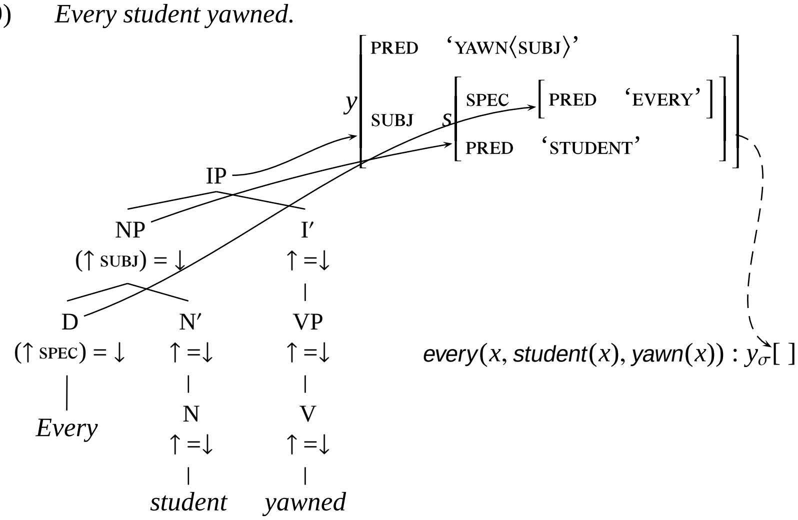
This illustrates the possibility of ambiguity resulting from two quantifiers which take the same semantic structure as their scope, but apply in a different order. Quantifier scope ambiguity can also arise when a quantifier can choose from multiple possible scope points, as in (23). In a glue setting, these possibilities arise naturally, given the different proofs available from the same set of meaning constructor premises.

8.2. Determiners and Nouns

We now turn to a sentence involving a determiner and noun, *Every student yawned*. This example illustrates how the meanings of the quantificational determiner *every* and the common noun *student* are combined. As we will see, a deduction from the meaning constructors for *every* and *student* produces a meaning similar to the one proposed in (61) for *everyone*, which can play a similar role in meaning assembly.

The c-structure, f-structure, and semantic representation for the sentence *Every student yawned* are:

(79) *Every student yawned.*



We propose the following lexical entry for the determiner *every*:

(80) *every* D $(\uparrow \text{PRED}) = \text{`EVERY'}$
$\lambda R.\lambda S.\mathit{every}(x, R(x), S(x))$:
$[((\text{SPEC}\ \uparrow)_\sigma\ \text{VAR}) \multimap ((\text{SPEC}\ \uparrow)_\sigma\ \text{RESTR})] \multimap$
$[\forall H.[(\text{SPEC}\ \uparrow)_\sigma \multimap H] \multimap H]$

The meaning constructor for *every* uses *inside-out functional uncertainty* (Chapter 6, Section 1.3) to refer to the f-structure for the noun phrase that contains it. The expression (SPEC ↑) in this entry refers to the f-structure in which the f-structure for *every* appears as the SPEC value, which is the f-structure labeled *s* in (79).

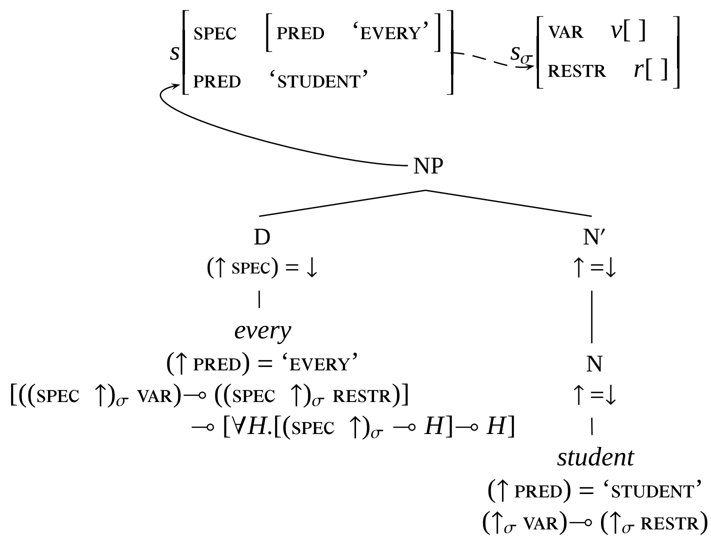
The lexical entry for the common noun *student* is:

(81) *student* N $(\uparrow \text{PRED}) = \text{`STUDENT'}$
$\lambda x.\mathit{student}(x) : (\uparrow_\sigma\ \text{VAR}) \multimap (\uparrow_\sigma\ \text{RESTR})$

According to the lexical entries in (80) and (81), the semantic structure for *every student* is complex and has internal structure; it contains two attributes, VAR and RESTR, with semantic structures as their values. The attribute VAR represents a variable of type e, and the attribute RESTR represents a restriction of type t on that variable — in this case, that the variable must range over individuals that are students.

These lexical entries, together with the standard English phrase structure rules, give rise to the structures shown in (82); to save space, only the glue sides of the meaning constructors for *every* and *student* are displayed, and the meaning sides are omitted:

(82) *every student*



Instantiating the ↑ and ↓ variables and using the labels v and r for the semantic structures (s_σ VAR) and (s_σ RESTR), as shown in (82), we have the meaning constructors in (83), labeled **[every]** and **[student]**:

(83) Meaning constructor premises for *every student*:

[every] $\lambda R.\lambda S.every(x, R(x), S(x)) \ : \ [v \multimap r] \multimap [\forall H.[s_\sigma \multimap H] \multimap H]$

[student] $\lambda x.student(x) \ : \ v \multimap r$

The meaning constructor for **[every]** requires two arguments: just as a transitive verb needs two semantic contributions, one from its subject and one from its object, a quantifier like *every* needs a semantic contribution from its restriction (the meaning of the common noun and any arguments or modifiers it might have) and its scope.

The first requirement is for a meaning for the restriction of the quantifier:

(84) $v \multimap r$

This requirement exactly matches the contribution of the common noun *student*, and the meaning of *student* becomes the restriction of the quantifier *every*.

The second requirement for the quantifier *every* is a meaning for its scope:

(85) $s_\sigma \multimap H$

As described in Section 8.1 for the quantificational pronoun *everyone*, the quantifier requires a contribution of the form $s_\sigma \multimap H$, whose meaning corresponds to the scope meaning S of *every*.

We can now deduce the meaning constructor for *every student* from the meaning constructors for *every* and *student*:

(86) Combining **[every]** and **[student]**:

$\lambda R.\lambda S.\mathit{every}(x, R(x), S(x)) : [v \multimap r] \multimap [\forall H.[s_\sigma \multimap H] \multimap H]$

This is the meaning constructor **[every]**. It requires a resource $v \multimap r$ corresponding to its restriction meaning R, and a resource $s_\sigma \multimap H$ corresponding to its scope meaning S, to produce a resource H for its scope semantic structure.

$\lambda x.\mathit{student}(x) : v \multimap r$

This is the meaning constructor **[student]**. It provides an implicational resource $v \multimap r$ corresponding to the meaning $\lambda x.\mathit{student}(x)$.

$\lambda S.\mathit{every}(x, \mathit{student}(x), S(x)) : \forall H.[s_\sigma \multimap H] \multimap H$

By combining **[every]** and **[student]** we get a result that is like the meaning constructor for *everyone*, except that the restriction of the quantifier *every* is specified to involve students.

The resulting meaning constructor for *every student* is in crucial respects fundamentally the same as the meaning for *everyone*. This is desirable because in terms of meaning construction, they behave alike; only the meanings associated with the semantic structures differ.

Completing the deduction, we have the meaning $\mathit{every}(x, \mathit{student}(x), \mathit{yawn}(x))$ for this sentence, which is the desired result:

(87) *Every student yawned.*

$$y\begin{bmatrix} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & s\begin{bmatrix} \text{SPEC} & \begin{bmatrix} \text{PRED} & \text{`EVERY'} \end{bmatrix} \\ \text{PRED} & \text{`STUDENT'} \end{bmatrix} \end{bmatrix}$$

$$\textbf{[every]} \quad \lambda R.\lambda S.\mathit{every}(x, R(x), S(x)) \ : \ [(s_\sigma\ \text{VAR}) \multimap (s_\sigma\ \text{RESTR})] \multimap [\forall H.[s_\sigma \multimap H] \multimap H]$$

$$\textbf{[student]} \quad \lambda x.\mathit{student}(x) \ : \ (s_\sigma\ \text{VAR}) \multimap (s_\sigma\ \text{RESTR})$$

$$\textbf{[yawn]} \quad \lambda x.\mathit{yawn}(x) \ : \ s_\sigma \multimap y_\sigma$$

$$\textbf{[every]}, \textbf{[student]}, \textbf{[yawn]} \vdash \mathit{every}(x, \mathit{student}(x), \mathit{yawn}(x)) : y_\sigma$$

9. REPRESENTING SEMANTIC FEATURES

Thus far, we have represented the meaning of the proper name *David* simply as *David*. This is sufficient for many purposes, but there are a number of properties associated with the name *David* that are not clearly represented by the meaning *David*. The name *David*, used in a particular context with a particular referent, may refer to an entity that is animate, for example a human or a dog. In the former case, the referent has the property of humanness; in the latter case, it does not. Most of the time, the precise referent of a name like *David*, and the particular semantic features associated with that referent, are not important for our purposes. In some situations, however, we need to be able to refer to a particular semantic feature associated with a meaning (and/or its referent). Rather than simply referring to $\uparrow_\sigma$, for example, we may need to refer to the fact that the value of the attribute ANIMATE associated with $\uparrow_\sigma$ is positive or negative. Example (88) shows the f-structure and meaning constructor for *David* in a context in which it is animate and human:

(88) F-structure and meaning constructor for *David*:

$$\begin{bmatrix} \text{PRED} & \text{`DAVID'} \end{bmatrix} \dashrightarrow \mathit{David}: \begin{bmatrix} \text{ANIMATE} & + \\ \text{HUMAN} & + \end{bmatrix}$$

There may be many other semantic and pragmatic features associated with a name like *David* in different contexts (Liao 2010, as cited by Dalrymple and Nikolaeva 2011, pages 78–79). As with functional structures, we usually do not explicitly represent every attribute in the semantic structure, but only those that are relevant to the current discussion. Semantic features may be contributed by, for example, syntactic structure, prosody, or discourse context. Semantic features will prove to be of particular importance to our discussion of information structure (Chapter 10).

Another semantic feature which will be relevant in Chapter 9 is REL. This feature is often used as a label representing the meaning of the eventuality denoted by a verb (i.e. the meaning of a verb minus any tense, aspect, or other grammatically contributed meaning). For example:

(89) F-structure and meaning constructor for *yawn*:

$$\left[\textsc{pred}\quad \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'}\right] \dashrightarrow \mathit{yawn} : \left[\textsc{rel}\quad \textsc{yawn}\right]$$

Note that the value of REL is merely a label that stands for the inherent meaning of the word concerned, and does not directly correpond either to the f-structure semantic form or to the meaning side of a meaning constructor. This accounts for the lack of subcategorization information in the semantic structure in (89).

10. TENSE AND ASPECT

In Section 4.1, the expression $\mathit{yawn}(\mathit{David})$ stood for the meaning of the sentence *David yawned*. Clearly, this analysis involves considerable simplification; in particular, it does not include a representation of the past tense of *yawned*. Often, such simplification is desirable, since it permits us to focus on other aspects of semantic composition with as little complication as possible. For this reason, such simplified representations will be used in the rest of this book. In this section, however, we delve more deeply into the semantics of verbs, to show how it is possible to make distinctions relating to tense and aspect.

Early work on tense and aspect in LFG represented such information purely in the f-structure; see, for example, Butt (2001b) and Glasbey (2001). Fry (1999b) was one of the first to propose a model of event semantics for LFG. Haug (2008b) and Bary and Haug (2011) present a detailed and relatively comprehensive model of the semantics of tense and aspect in LFG in the context of participial modification (see also Lowe 2012). The approach presented here is largely based on the proposals of Haug (2008b), Bary and Haug (2011), and Lowe (2012), though departing from their assumptions in certain minor ways.

Expressions such as $\mathit{yawn}(\mathit{David})$ and $\lambda x.\lambda y.\mathit{select}(x, y)$ treat the meaning of a verb as a function that takes as arguments the meanings of the syntactic arguments of the verb. That is, just as *David* is a syntactic argument of *yawn* in the sentence *David yawns*, so the meaning David is a semantic argument of the meaning yawn in $\mathit{yawn}(\mathit{David})$. This is a convenient simplification, but it does not enable us to explicitly distinguish the different semantic roles that syntactic arguments may have. There is clearly a semantic difference between the roles played by the subject arguments of the verbs *yawn* and *select*, for example: the former is a THEME, while the latter is an AGENT. Some models of argument structure, discussed in Chapter 9, assume that semantic roles are also relevant for syntactic subcategorization requirements and alternations. Such models represent semantic roles at argument structure, but these representations do not imply that such relations are not part of the semantics; rather, they tend to leave the semantic representation to one side. Other approaches to argument structure seek to separate semantic roles from argument structure representations as far as possible. We maintain that it is desirable to represent the semantic relations between verbs and their arguments as a part of the meaning representation.

In order to capture the semantic aspects of the relationship between a verb and its syntactic arguments, we can adopt a "neo-Davidsonian" approach to the representation of syntactic arguments, treating semantic arguments as predicates of events (Davidson 1967; Dowty 1989; Parsons 1990; Schein 1994). Thus far, our representation has not distinguished event types from individual events. We now use *yawn* to refer to an event type, that is, the set of events that can be characterized as consisting primarily of yawning. This predicate holds of individual events. Events are a special kind of individual, and we therefore extend our understanding of the type e (Section 4.1.3) so that e ranges over both events and entities. The meaning constructor in (90) represents a function from events of unspecified nature to the proposition that the event is a yawning-type event:

(90) $\lambda x.\mathit{yawn}(x) : \langle e \rightarrow t \rangle$

This meaning constructor is identical in form to that given in (15) on page 301. It is now used, however, in an entirely different way. The variable x no longer represents the subject of *yawn*, as in previous sections, but represents an event that is characterized as an event of yawning. The simplified expression $\mathit{yawn}(\mathit{David})$ can now be expressed in a rather different form as:

(91) $\lambda x.\mathit{yawn}(x) \wedge \mathit{theme}(x, \mathit{David}) : (\uparrow_\sigma \text{ EV}) \multimap \uparrow_\sigma$

This meaning constructor encodes the information that David is the THEME of an event x, which is an event of yawning. This expression therefore represents a function from events in general to propositions in which *David* is the THEME of an event of yawning. In the glue expression, $(\uparrow_\sigma \text{ EV})$ refers to a semantic structure labeled EV, which represents the event variable of the proposition.

(92) $\left[\text{PRED} \quad \text{'YAWN}\langle\text{SUBJ}\rangle\text{'} \right] \xrightarrow{\mathit{yawn};} \left[\text{EV} \quad [\,] \right]$

In the same way, we previously used the expression $\mathit{select}(\mathit{David}, \mathit{Chris})$ to represent the meaning of the sentence *David selected Chris*. Now, the semantic relation between the verb *select* and its arguments can be more accurately represented as in (93), where *David* is specified as the agent of the selecting event, and *Chris* as its theme:[6]

(93) $\lambda x.\mathit{select}(x) \wedge \mathit{agent}(x, \mathit{David}) \wedge \mathit{theme}(x, \mathit{Chris}) : (\uparrow_\sigma \text{ EV}) \multimap \uparrow_\sigma$

This meaning expresses that David is the AGENT, and Chris the THEME, of an event x, which is an event of selecting.

[6] On thematic roles and semantic structure, see Chapter 9, Section 2.

Now that we are able to refer to a particular event (or set of events), we are able to specify the temporal and aspectual characteristics of that event. In order to do this, we need a theory of the representation of the semantics of tense and aspect.

Reichenbach (1947) was one of the first to develop a formal model of tense and aspect relations by reference to a limited number of temporal variables. This model has been further developed by Kamp and Reyle (1993), and is highly influential; a very similar formal approach is that of Klein (1992, 1994, 1995). As discussed by Kamp and Reyle (1993), tense and aspect can be modeled with reference to the following four points in time relative to the discourse:[7]

(94) E – event time, i.e. the time during which or at which an event occurs.
R – reference time, i.e. the time referred to by the utterance.
P – perspective time, i.e. the “now” point of temporal deixis.
S – speech time, i.e. the moment of utterance.

In most simple sentences S and P are equivalent, and even in complex sentences the relation of P to S can be determined purely by reference to E, R and P; hence S is generally omitted from the formalization of tense and aspect, and we will do so here. Temporal and aspectual relations are indicated using logical symbols indicating precedence, inclusion and overlap. In line with Klein (1992), tense is formalized as the relation between R and P, while aspect is formalized as the relation between E and R. Table 8.1 illustrates the major temporal and aspectual relations, and their logical representation.[8]

Table 8.1: Temporal and aspectual relations

	Tense			Aspect		
Name	Present	Past	Future	Imperfective	Perfective	Anterior
Repr.	P⊆R	R≺P	P≺R	R⊆E	E⊆R	E≺R

The symbols ≺ and ≻ indicate a precedence relation; thus, R≺P (or, equivalently, P≻R) indicates that the time referred to by the utterance entirely precedes the perspective time of the utterance. This is the basic meaning of relative past time. The symbols ⊆ and ⊇ indicate an inclusion relation: E⊆R or R⊇E indicates

[7] These points may be true points, that is instants with no measurable temporal extent, or they may be periods extending over an interval of time.

[8] The formalization of tense and aspect presented here may be too simplistic to account adequately for the wide range of temporal and aspectual features expressed in different ways crosslinguistically. The variety of use of the English perfect, for example, cannot be accounted for under this system without assuming that it has two recursively applied aspect properties. Nevertheless, the system presented here has relatively wide currency, and is adequate for the demonstration of tense-aspect semantics provided here.

that E is included within or coextensive with R. This is a possible definition of perfective aspect within this framework.[9]

In order to specify the tense and aspect properties of an event, we therefore need to refer to the event time E of that event. We use the function τ (tau) to do this: $\tau(x)$ is the temporal interval (which may or may not be a point) during which an event x occurs (Krifka 1989). Aspect describes the relation between $\tau(x)$ and the reference time R of an utterance. Let us take as a concrete example the sentence *David yawned*. We assume for the sake of argument that the English simple past expresses perfective aspect and past tense. The meaning of perfective aspect is encoded in the meaning constructor in (95), labeled **[perf]**:

(95) **[perf]** $\lambda Q.\lambda r.\exists x.Q(x) \wedge \tau(x) \subseteq r : [(\uparrow_\sigma \textsc{ev}) \multimap \uparrow_\sigma] \multimap [(\uparrow_\sigma \textsc{rt}) \multimap \uparrow_\sigma]$

The term $(\uparrow_\sigma \textsc{rt})$ in the glue expression refers to the value of the RT (Reference Time) attribute in the semantic structure $\uparrow_\sigma$ for the verb, representing its reference time. On the meaning side, an existential quantifier is introduced to bind the event variable x, and an inclusion relation ($\subseteq$) is specified between $\tau(x)$, the time of the event x, and the variable r, which represents the reference time.

The meaning of the verb *yawn* in combination with its subject argument *David* is given by the meaning constructor in (91), repeated as (96) and labeled **[David-yawned]**:

(96) **[David-yawned]** $\lambda x.\mathit{yawn}(x) \wedge \mathit{theme}(x, \mathit{David}) : (\uparrow_\sigma \textsc{ev}) \multimap \uparrow_\sigma$

Combining the meaning constructor **[David-yawned]** with the meaning constructor **[perf]** results in a meaning constructor in which the event variable is quantified, but a new variable — that of the reference time — is introduced and specified as having a particular relation to the event time of the quantified event. This meaning constructor, labeled **[David-yawned-perf]** in (97), represents the perfective aspect of the meaning of *David yawned*, but does not include the meaning of its tense:

(97) **[David-yawned-perf]**

$$\lambda r.\exists x.\mathit{yawn}(x) \wedge \mathit{theme}(x, \mathit{David}) \wedge \tau(x) \subseteq r : (\uparrow_\sigma \textsc{rt}) \multimap \uparrow_\sigma$$

The meaning of tense is formally similar to the meaning of aspect. Tense quantifies the reference time R of an event (RT) in relation to a perspective time P (PT). The meaning of past tense, for example, can be represented as in (98); we give this meaning constructor the label **[past]**:

(98) **[past]** $\lambda Q.\lambda p.\exists r.Q(r) \wedge r \prec p : [(\uparrow_\sigma \textsc{rt}) \multimap \uparrow_\sigma] \multimap [(\uparrow_\sigma \textsc{pt}) \multimap \uparrow_\sigma]$

We can combine the meaning constructor **[past]** with the meaning constructor **[David-yawned-perf]** to produce the meaning constructor in (99), labeled **[David-yawned-perf-past]**:

[9] The alternative is *proper* inclusion: $E \subset R$, meaning that E is included within R but R is not included within E. Following Kiparsky (1998) and Haug (2008b, page 294, fn. 1), among others, we assume improper inclusion here.

(99) **[David-yawned-perf-past]**

$$\lambda p.\exists r.\exists x.\mathit{yawn}(x) \wedge \mathit{theme}(x, \mathit{David}) \wedge \tau(x) \subseteq r \wedge r \prec p : (\uparrow_\sigma \text{PT}) \multimap \uparrow_\sigma$$

This meaning constructor represents a function from perspective times to the proposition that an event of yawning occurred, viewed perfectively and represented as occurring prior to a reference time, and includes the information that *David* is the theme of this event. The perspective time variable p is still lambda-bound in (99). In some contexts, this variable may be anchored in relation to another verbal meaning in the clause, for example in the case of non-finite verb forms like participles, whose temporal reference is usually anchored by the main clause. The temporal reference of a finite verb, on the other hand, is independent within its clause, depending rather on discourse and extra-linguistic context for its interpretation. The meaning of a finite verb must therefore include a further specification, which we can label **[finiteness]**, which quantifies the perspective time (PT) of the sentence.

(100) **[finiteness]** $\lambda Q.\exists p.Q(p) : [(\uparrow_\sigma \text{PT}) \multimap \uparrow_\sigma] \multimap \uparrow_\sigma$

This meaning constructor can combine with a meaning constructor like **[David-yawned-perf-past]** in (99). It augments the meaning by specifying that an appropriate perspective time exists. This is a convenient simplification, since the perspective time must be quantified in relation to some other temporal anchor, which may be discourse internal or discourse external. This quantification is determined by pragmatic interpretation — by reference to extra-clausal or extra-linguistic context — and so goes beyond the limits of our semantic theory, which is restricted to clause-internal relations.

Let us now summarize the derivation of the more complex, but more accurate, meaning which we have obtained for the sentence *David yawned*:

(101) Meaning constructor premises for *David yawned*:

[David]	$\mathit{David} \ : \ d_\sigma$
[yawn]	$\lambda y.\lambda x.\mathit{yawn}(x) \wedge \mathit{theme}(x, y) \ : \ d_\sigma \multimap [e_\sigma \multimap y_\sigma]$
[perf]	$\lambda Q.\lambda r.\exists x.Q(x) \wedge \tau(x) \subseteq r \ : \ [e_\sigma \multimap y_\sigma] \multimap [r_\sigma \multimap y_\sigma]$
[past]	$\lambda Q.\lambda p.\exists r.Q(r) \wedge r \prec p \ : \ [r_\sigma \multimap y_\sigma] \multimap [p_\sigma \multimap y_\sigma]$
[finiteness]	$\lambda Q.\exists p.Q(p) \ : \ [p_\sigma \multimap y_\sigma] \multimap y_\sigma$

From these premises, we can make the following logical deduction:

(102) $\textsf{David} : d_\sigma$ This is the meaning constructor **[David]**.

$\lambda y.\lambda x.\textsf{yawn}(x) \wedge \textsf{theme}(x, y) : d_\sigma \multimap [e_\sigma \multimap y_\sigma]$

This is the meaning constructor **[yawn]**. On the glue side, if semantic resources for the theme d_σ and an event e_σ can be found, a resource for the sentence can be produced. On the meaning side, the one-place predicate *yawn* is applied to the event variable x, and the two-place predicate *theme* is applied to the event meaning x and the subject meaning y.

$\lambda Q.\lambda r.\exists x.Q(x) \wedge \tau(x) \subseteq r : [e_\sigma \multimap y_\sigma] \multimap [r_\sigma \multimap y_\sigma]$

This is the meaning constructor **[perf]**. On the glue side, if a semantic resource of the form $[e_\sigma \multimap y_\sigma]$ can be found, a resource of the form $[r_\sigma \multimap y_\sigma]$ can be produced. On the meaning side, the variable x is existentially quantified ($\exists$), and the temporal extent of x, the event time $\tau(x)$, is defined as being included within the temporal extent of a new variable r representing the reference time.

$\lambda Q.\lambda p.\exists r.Q(r) \wedge r \prec p : [r_\sigma \multimap y_\sigma] \multimap [p_\sigma \multimap y_\sigma]$

This is the meaning constructor **[past]**. On the glue side, if a resource of the form $[r_\sigma \multimap y_\sigma]$ can be found, a resource of the form $[p_\sigma \multimap y_\sigma]$ can be produced. On the meaning side, the variable r is existentially quantified, and its temporal extent is defined as wholly preceding ($\prec$) the temporal extent of a new variable p representing the perspective time.

$\lambda Q.\exists p.Q(p) : [p_\sigma \multimap y_\sigma] \multimap y_\sigma$

This is the meaning constructor **[finiteness]**. On the glue side, if a resource of the form $[p_\sigma \multimap y_\sigma]$ can be found, a resource for the sentence can be produced. On the meaning side, the perspective time variable p is existentially quantified, producing a full meaning for the sentence.

$\exists x.\exists r.\exists p.\textsf{yawn}(x) \wedge \textsf{theme}(x, \textsf{David}) \wedge \tau(x) \subseteq r \wedge r \prec p : y_\sigma$

We have produced a semantic structure y_σ for the sentence *David yawned*, associated with the full meaning for the sentence.

In this way, then, it is possible to represent the semantics of tense and aspect using the glue framework which we have presented in this chapter. The representation is highly complex, however, even for a sentence as simple as *David yawned*. In subsequent chapters, we will ignore the semantic contributions of tense and aspect by finite verbs and other words, so as not to obscure the points made.

11. FURTHER READING AND RELATED ISSUES

This chapter has been devoted to an exploration of linguistic meaning and the syntax-semantics interface. The intention has been to give the reader the linguistic intuitions behind the analyses, and we have not emphasized the formal and mathematical properties of the glue language, linear logic. The presentation of analyses in subsequent chapters is also aimed primarily at an intuitive understanding of how meaning deductions work. It is important to keep in mind, however, that despite the informal nature of the presentation here and in the following chapters, our theory of meaning composition is grounded in a mathematically precise, rigorously defined logic. We will not give a more technically oriented introduction or overview discussion of linear logic in this volume, since such material is readily available from other sources. Dalrymple et al. (1999b) give a more detailed introduction to linear logic in the current setting (see also Dalrymple et al. 1995e). Linear logic originated in the work of Girard (1987); a very accessible general overview is given by Scedrov (1993), and Crouch and van Genabith (2000) provide an in-depth treatment with a linguistic orientation. For the logically inclined, the appendix to this chapter presents the proof rules for our fragment of linear logic.

Besides the work mentioned in this chapter, there are a number of papers on linguistic issues relating to glue theory. The papers in Dalrymple (1999) provide an overview of the theory, as well as discussions of formal aspects of the theory and particular linguistic phenomena. Included in this volume are treatments of quantifier scoping constraints (Crouch and van Genabith 1999), intensionality and quantifier scope (Dalrymple et al. 1997), negative polarity (Fry 1999a), and dynamic and underspecified semantics (van Genabith and Crouch 1999a). It is worth noting that the meaning constructors we assume in this book are cast in the so-called "Curry-Howard" or "new glue" format, conforming to the proposals made by Dalrymple et al. (1999a). This format departs from most work in the glue framework carried out in the twentieth century, including most of the papers collected in Dalrymple (1999), in which the meaning constructor for *David* is written as $\uparrow_\sigma \rightsquigarrow \mathit{David}$ (read as '$\uparrow_\sigma$ means *David*'). The two formats have different expressive power, and in fact the "new glue" format adopted here and in most glue work since 1999 is the more constrained of the two; see Dalrymple et al. (1999a) for more discussion of the two formats and the formal differences between them.

Additional work within the glue framework includes work on ellipsis (Crouch 1999; Asudeh and Crouch 2002b), translation within the semantic framework of Underspecified Discourse Representation Theory (Crouch et al. 2001), the German split NP construction (Kuhn 2001c), constructional meaning (Asudeh et al. 2008, 2013), non-restrictive relative clauses (Arnold and Sadler 2010, 2011), adjectival constructions (Al Sharifi and Sadler 2009), the semantics of concomitance (Haug 2009), affected experiencer constructions (Arnold and Sadler 2012), optional or ambiguous arguments (Asudeh and Giorgolo 2012; Giorgolo and Asudeh 2012b), and distance distributivity (Przepiórkowski 2014a,b, 2015). The logic of pronominal resumption is treated in detail by Asudeh (2012), and will be discussed further in Chapter 17, Section 6.4.

Emendations or extensions to the glue system which we have presented here have been proposed by some authors, but we omit discussion of these issues. Kokkonidis (2007) discusses the development of glue theory and proposes a “first-order” glue system that differs somewhat from the “second-order” system used in this book, as well as much other glue work; Bary and Haug (2011) adopt and extend Kokkonidis’ proposals. Andrews (2007b, 2008, 2011) proposes a purely propositional glue system, and discusses the formal integration of semantic structure into the grammatical architecture, proposing an alternative view of the relation between semantic structure and f-structure. For Andrews, meaning constructors are not directly associated with lexical entries in the way that we have assumed in this chapter; rather, they are associated with special lexical entries that link meanings to f-structures. Lowe (2014b) discusses the role and function of semantic structures within the LFG architecture, and proposes a reformulation of meaning constructors so that each lexical meaning is associated, via its glue term, with a single semantic structure.

Giorgolo and Asudeh (2011a) propose a new formal treatment of the meaning contribution of expressions such as expressives, epithets, appositives, and nonrestrictive relative clauses: such expressions are often taken to motivate a multidimensional semantics, encompassing an “at-issue” dimension and a “side-issue” dimension (Potts 2005). Giorgolo and Asudeh’s treatment of multi-dimensional meaning extends the formal glue model to incorporate *monads*, a construction from category theory; the model is explored further in their work on the argument-adjunct distinction and argument linking (Giorgolo and Asudeh 2012b), on conventional implicatures (Giorgolo and Asudeh 2012a), and on opaque contexts (Giorgolo and Asudeh 2014). Arnold and Sadler (2010, 2011) provide an alternative treatment of multidimensional meaning which does not incorporate monads, exploring the possibility of extending the projection architecture to separate at-issue from side-issue meaning, and also exploring an alternative treatment which assumes a single semantic projection associated with a meaning pair.

We will not discuss proof methods or algorithms for deduction in linear logic, since this material is widely available for consultation by those interested in formal and computational aspects of glue theory. Girard (1987) introduced the notion of *proof nets* for proofs in the fragment of linear logic we use; for a lucid description of the use of proof nets for deduction in the glue approach, see Fry (1999a). Efficient proof techniques for glue semantic deductions are also explored by Gupta and Lamping (1998).

APPENDIX: PROOF RULES FOR LINEAR LOGIC

The following table of proof rules for the glue fragment of linear logic is adapted from Crouch and van Genabith (2000). The analyses we present in this book do not use the multiplicative conjunction operator $\otimes$, but since this operator is often used in glue analyses, particularly in some treatments of anaphora, we include it here for reference.

$\multimap$	$\begin{array}{c}[A]^i \\ \vdots \\ B \\ \hline A \multimap B\end{array}$	$\begin{array}{cc}A & A \multimap B \\ \hline \multicolumn{2}{c}{B}\end{array}$
$\otimes$	$\begin{array}{cc}A & B \\ \hline \multicolumn{2}{c}{A \otimes B}\end{array}$	$\begin{array}{cc} & [A]^i[B]^j \\ & \vdots \\ A \otimes B & C \\ \hline \multicolumn{2}{c}{C}\end{array}$
$\forall$	$\begin{array}{c}A \\ \hline \forall x.A[x/a]\end{array}$ provided a does not occur in any assumptions that A depends on.	$\begin{array}{c}\forall x.A \\ \hline A[a/x]\end{array}$

In these rules, $[\ ]^i$ indicates the discharge of a hypothesis labeled i.

9

ARGUMENT STRUCTURE AND MAPPING THEORY

In this chapter we explore *argument structure* and its relation to syntax, particularly concentrating on its role in determining the grammatical functions of the semantic arguments of a predicate. We will examine different views of the representation and content of argument structure, and outline the theory of the relation between thematic roles and grammatical functions. The first five sections explore issues relating to the theory of argument structure. Sections 6 to 9 focus on the analysis of some important phenomena, and further issues relating to grammatical functions and argument structure are considered in Section 10.

1. SYNTAX, SEMANTICS, AND ARGUMENT STRUCTURE

As discussed in Chapter 8, Section 2, it can be easily demonstrated that syntax and semantics are separate structures, separately constrained, by a consideration of verbs like *eat* or *rain* in examples such as:

(1) a. *Chris ate.*

b. *It rained.*

Semantically, the verb *eat* refers to a two-place relation between an AGENT, or individual who eats, and a PATIENT, or entity that is eaten. Syntactically, however, the verb *eat* has an intransitive use, illustrated in (1a), where its only argument is the AGENT; the PATIENT argument is understood but is not included in the sentence. Evidence that the verb *eat* has an intransitive use is given by the possibility of *out*-prefixation, as discussed by Bresnan (1982d). Bresnan shows that only intransitive verbs can participate in *out*-prefixation:

(2) a. *The lamp shines./The lamp outshines the candle.*

b. *The Brownies found the treasure./*The Brownies outfound the Girl Scouts in the treasure hunt.*

The verb *eat* can participate in *out*-prefixation, indicating that it has an intransitive use:

(3) *Chris outate David.*

Thus, the verb *eat* can be syntactically monovalent, requiring only a SUBJ argument, whereas it is semantically bivalent, denoting a relation between two entities.

Conversely, a verb like *rain* in (1b) requires a syntactic SUBJ argument, but semantically denotes a predicate that does not take an argument; it does not make sense to ask **Who/What rained?*, or to replace the SUBJ argument of *rain* by any other argument:

(4) **He/David/Something rained.*

Here too, syntactic and semantic valence are different: *rain* requires a syntactic argument that does not play a semantic role. These simple examples make it clear that syntactic and semantic argument structures are different and must be represented separately.

The influence of semantics on syntactic form is shown by the predictable nature of the syntactic realization of arguments of newly coined verbs. Alsina (1996, Chapter 1) illustrates this point by considering the nonce word *obliquate*, which he defines as meaning "to build or place in an oblique orientation." As he notes, the possibilities for syntactic expression of the arguments of this verb are limited:

(5) a. *Jim obliquated the door of the closet.*

b. **The door of the closet obliquated Jim.*

Because *obliquate* is a made-up verb, anyone encountering these sentences cannot have heard sentences like them before. Thus, any constraints on the way the arguments of this verb are realized cannot be due to any syntactic or morphological priming. Instead, the pattern of acceptability in (5) must be ascribed to constraints imposed by the meaning of the verb.

Which aspects of semantics are relevant for determining syntactic roles? Pinker (1989) outlines two main hypotheses (see also Mohanan 1994): on the first hypothesis, which Pinker calls “Unrestricted Conceptual Representation,” any kind of semantic or culturally salient distinction can be reflected in syntax and can constrain syntactic form and syntactic relations. The second hypothesis, the “Grammatically Relevant Subsystem” hypothesis, is more restricted: only certain semantic features, those represented at what is generally termed *argument structure*, are relevant for syntax. As Pinker notes, the second hypothesis is more satisfying. It allows not only for a more precise characterization of argument structure, but also for the prospect of an explanatory theory of the relation between argument structure and syntax, as well as a realistic theory of language learning. Work in LFG adheres to the “Grammatically Relevant Subsystem” paradigm, with different researchers adopting different views of argument structure and the subset of semantic information it contains.

In this chapter, we will explore some influential theories of argument structure and its representation in LFG, and we will examine some proposed constraints on the relation between argument structure and syntax. We will concentrate primarily on the theory of argument structure and its role in mapping between argument roles and grammatical functions.[1]

2. CONTENT AND REPRESENTATION OF ARGUMENT STRUCTURE

It is generally agreed that argument structure contains some amount of semantic information, but researchers do not agree on how much. Some claim that there is very little semantic information in argument structure; others hold that argument structure is semantically richer, individuating thematic roles like AGENT, THEME, or GOAL, and even drawing aspectual and other semantic distinctions.

A number of different views of argument structure have been explored since the early days of LFG. As discussed in Chapter 8, Section 2, Kaplan and Bresnan (1982) propose that the semantic form value of the PRED attribute encodes the relation between thematic roles and syntactic functions (see also Bresnan 1982a,c), as in the following semantic form for the verb *give*:

(6) Semantic form for *give* (Kaplan and Bresnan 1982):

$$\text{‘give}\langle\ \underset{\text{AGENT}}{\overset{\text{SUBJ}}{—}}\ ,\ \underset{\text{THEME}}{\overset{\text{OBJ}}{—}}\ ,\ \underset{\text{GOAL}}{\overset{\text{OBL}_{\text{GOAL}}}{—}}\ \rangle\text{’}$$

[1] In this book, we will not provide much discussion of the interaction of argument structure with other grammatical processes. See Manning (1996a,b) for a very interesting theory of the syntactic role of argument structure and its interactions with functional structure. Manning proposes that what he calls construal processes such as binding, determination of imperative addressee, and control in adverbial and complement clauses are sensitive to relations at argument structure rather than a syntactic representation like functional structure. For a critical evaluation of Manning’s proposals, and an alternative approach to subjecthood, see Falk (2006), particularly Chapter 7, Section 4.

This expression indicates that *give* has three argument "slots", which we refer to as *argument positions*. These argument positions are associated with the roles of AGENT, THEME, and GOAL; such roles are often referred to as *thematic roles*. The three argument positions are also associated with syntactic functions: the AGENT with SUBJ, the THEME with OBJ, and the GOAL with OBL_{GOAL}. As Kaplan and Bresnan (1982) note, the angled brackets are supposed to remind us of the parentheses commonly used in logical expressions, so that the semantic form is thought of as a kind of logical formula encoding some aspects of the meaning of the sentence as well as the relation between thematic roles and their grammatical functions.

Since these first steps, researchers in LFG have sought to provide an explicit view of the content and representation of argument structure and its place in the overall grammar. Proposals for representing argument structure are often based on one of two rather different sources: Zaenen (1993), Alsina (1996), Rákosi (2008), Ackerman and Moore (2013) and others adopt and modify the Proto-Role argument classification proposals of Dowty (1991), while Butt (1995, 1998), Broadwell (1998), and others present analyses based on the Conceptual Semantics framework of Jackendoff (1983, 1990).

Alsina (1993, 1996) assumes that argument structure is represented via a refinement of the traditional notion of semantic form, appearing in the f-structure as the value of the PRED feature. In line with much research on argument structure and thematic roles, Alsina relies on an ordering of the arguments of a predicate according to a semantically motivated hierarchy of thematic roles (to be described in Section 4.2 of this chapter): for example, arguments bearing the AGENT role are higher on the hierarchy than PATIENTS. Alsina claims, however, that the differences among particular thematic roles like AGENT and PATIENT are best represented semantically rather than at argument structure; in his theory, such distinctions do not play a direct role in determining the syntactic functions of arguments.

Besides the hierarchical ordering imposed on the arguments of a predicate, Alsina builds on work by Dowty (1991) on Proto-Role argument classification, distinguishing between *proto-agent* and *proto-patient* properties of arguments. Unlike Dowty, however, Alsina assumes a set of criterial definitions for proto-agent and proto-patient arguments; for example, he proposes that a causer argument with volitional involvement is necessarily classified as a proto-agent, while an "incremental theme" argument is a proto-patient. Arguments that do not meet these criteria are not assigned proto-role status. Alsina (1996) provides the following argument structure representations for the verbs *come* and *give*:

(7) Argument structures for *come* and *give* (Alsina 1996):

$$\begin{bmatrix}\text{PRED} & \text{`COME}\langle[\text{P-P}]\ [\ ]\rangle\text{'}\end{bmatrix}$$

$$\begin{bmatrix}\text{PRED} & \text{`GIVE}\langle[\text{P-A}]\ [(\text{P-P})]\ [\text{P-P}]\rangle\text{'}\end{bmatrix}$$

According to these representations, the verb *come* has two arguments: the individual who comes is the proto-patient (P-P), and the destination argument bears no proto-role status and so is not labeled as either P-A or P-P. The verb *give* has three arguments: a proto-agent (P-A) or giver; a recipient argument that is optionally classified as a proto-patient (indicated by parentheses around the P-P label), depending on whether or not it is causally affected; and a second proto-patient, the entity that is given. On Alsina's view of argument structure, no other semantic information appears in argument structure besides the proto-role status of each argument and the ordering of arguments according to the thematic hierarchy.

Zaenen (1993) also builds on Dowty's proposals to define argument structure in terms of semantically based properties of a predicate. Unlike Dowty, Zaenen does not assume that these properties relate to semantic entailments of particular uses of the predicate. Instead, Zaenen proposes that predicates have lexically specified, semantically definable characteristics that she terms *dimensions*; for instance, a predicate has a volitional dimension if it can be used with an adverb like *on purpose*. The existence of a volitional dimension in the argument structure of a verb does not entail that every use of the verb denotes a volitional act; rather, the verb denotes an act that can be volitional. Based on these semantic dimensions, Zaenen (1993) proposes a set of role-defining properties that the arguments of a verb can bear, and the assignment of a grammatical function to an argument is made on the basis of these properties.

In contrast with Proto-Role-theoretic accounts, Butt (1995) proposes a semantically richer theory of argument structure, based on the Conceptual Semantics approach of Jackendoff (1990). On her view, the argument structure for a verb like *give* is:

(8) Lexical Conceptual Structure for *give* (Butt 1995):

$$\begin{bmatrix} \text{give} \\ \begin{bmatrix} \text{CS}([\alpha], \text{GO}_{\text{Poss}}([\ ], \text{TO}[\beta])) \\ \text{AFF}^{+}([\ ]^{\alpha},) \\ \text{ASP}(\underline{\quad}, \underline{\quad}, \underline{\quad}) \end{bmatrix}_{\text{EVENT}} \end{bmatrix}$$

This argument structure representation is tripartite. The first line is the Thematic Tier, representing causation, motion and location: here, that the "cause" relation CS holds between an actor α and an event GO_{Poss} in which some entity comes to be possessed by a beneficiary β. The second line is the Action Tier, which encodes information about agency and affectedness. The function AFF (affect) in the Action Tier indicates actor/patient/beneficiary relations; AFF^{+} is a relation between an actor and a beneficiary (AFF^{-} would indicate that the arguments are an actor and a patient). In this example, the second line indicates that α is the first argument of the AFF^{+} predicate and is therefore the AGENT. As Butt points out, the Action Tier represents roughly the same subset of information that is taken to be relevant for the Proto-Role theory of Dowty (1991). An innovation in Butt's approach is the postulation of an Aspectual Tier, represented on the third line, which indicates whether the beginning, middle, and end of the event are lexically specified; in the case of the verb *give*, neither the inception, duration, nor end point of the event is intrinsically specified. Compare this with the Hindi-Urdu verb *b*^{h}*uul* 'forget' shown in (9), which is negatively specified (with the integer

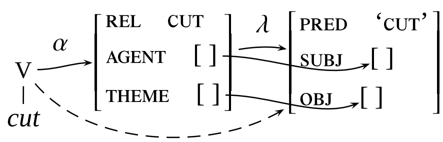
0) for inception (Butt 1995, page 151). Butt shows that aspectual information is important in characterizing the mapping relation for complex predicates in Urdu.

(9) Lexical Conceptual Structure for *bhuul* 'forget' (Butt 1995):

$$\begin{bmatrix} \text{bhuul 'forget'} \\ \begin{bmatrix} \text{CS}([\alpha], \text{GO}_{\text{Info}}([\ ], \text{FROM}[\alpha])) \\ \text{AFF}([\ ]^{\alpha},) \\ \text{ASP}(0, \underline{\quad}, \underline{\quad}) \end{bmatrix}_{\text{EVENT}} \end{bmatrix}$$

Butt et al. (1997) assume a more traditional view of argument structure in which the arguments of a predicate bear particular thematic roles like AGENT, GOAL, and THEME. Unlike many other approaches, they provide an explicit characterization of the relation between argument structure and other grammatical structures:

(10) C-structure, argument structure, and f-structure for *cut* (Butt et al. 1997):



$\phi = \lambda \circ \alpha$

On this view, argument structure bears a direct relation to c-structure, defined by the correspondence function α from c-structure nodes to argument structures. In turn, argument structure is related to f-structure by a function λ.[2] Thus, the familiar ϕ mapping between c-structure nodes and f-structures, described in Chapter 4, Section 1 and represented by the dashed arrow in (10), is redefined as the composition $\lambda \circ \alpha$ of the α and λ functions.

Butt et al. propose that the argument roles required by a predicate at argument structure are specified in the meaning constructor (Chapter 8) which represents the lexical meaning of the predicate. On this view, the verb *cut* has the following meaning constructor:

(11) $\lambda x.\lambda y.cut(x,y) : (\hat{*}_{\alpha}\ \text{AGENT})_{\lambda\sigma} \multimap (\hat{*}_{\alpha}\ \text{THEME})_{\lambda\sigma} \multimap \hat{*}_{\alpha\lambda\sigma}$

In the glue term in (11), $\hat{*}_{\alpha}$ refers to the argument structure projected via the α function from the immediately dominating (mother) c-structure node ($\hat{*}$), and ($\hat{*}_{\alpha}$ AGENT) refers to the AGENT feature in the a-structure for this word. $(\hat{*}_{\alpha}\ \text{AGENT})_{\lambda\sigma}$ then refers to the semantic structure projected from the f-structure projected from this a-structure feature. Crucially, no direct reference is made to the grammatical function label. Based on these relations between structures, Butt et al. (1997) propose a theory of mapping between argument roles and grammatical functions in which candidate mappings defined by the λ function are evaluated and the

[2]Note that this use of λ is different from the λ projection from c-structure nodes to node labels, discussed in Chapter 5, Section 1.2. It is also unrelated to the λ operator used in semantic representation and introduced in Chapter 8, Section 4.1.1.

highest-ranking candidate mapping is selected. This model of argument structure is also utilized by Asudeh et al. (2008, 2013); for further details, see Section 10.5.2 of this chapter.

A rather different, though not incompatible, approach to argument structure — one which has significant consequences for the LFG architecture — has been developed by Asudeh and Giorgolo (2012). In contrast with much LFG work, Asudeh and Giorgolo propose an approach in which no separate level of argument structure exists; like Butt et al.'s proposal, the approach includes a glue semantics component. Asudeh and Giorgolo's approach shares some of the key goals of Butt et al.'s model, but solves some problems with Butt et al.'s approach by positing a connected semantic structure.

In developing their analysis, Asudeh and Giorgolo make a number of new proposals regarding the representation of argument structure in LFG. Firstly, they argue that the semantic form does not encode syntactic subcategorization requirements. For example, the lexical entry for the verb *select* specifies the verb's semantic form as in example (12a) and does not, as more usually assumed, include an argument list, as in (12b):

(12) a. $(\uparrow \textsc{pred}) = \text{`}\textsc{select}\text{'}$ (Asudeh and Giorgolo 2012)

b. $(\uparrow \textsc{pred}) = \text{`}\textsc{select}\langle\textsc{subj},\textsc{obj}\rangle\text{'}$ (standard representation)

The f-structure principles of Completeness and Coherence, which in a standard LFG approach depend upon the subcategorization specifications in f-structure PRED values, are enforced in Asudeh and Giorgolo's analysis by the resource sensitivity of the glue semantics (see Chapter 8, Section 7.1) for all non-expletive arguments.

Asudeh and Giorgolo (2012) propose that grammatical functions at f-structure are directly associated with s-structure attributes in the lexical entries of predicates. For example, under this approach, the lexical entry for English *selected* contains at least the following information:

(13) *selected* V $(\uparrow \textsc{pred}) = \text{`}\textsc{select}\text{'}$
$(\uparrow \textsc{tense}) = \textsc{pst}$

$(\uparrow_\sigma \textsc{rel}) = \text{`}\textsc{select}\text{'}$
$(\uparrow \textsc{subj})_\sigma = (\uparrow_\sigma \textsc{arg}_1)$
$(\uparrow \textsc{obj})_\sigma = (\uparrow_\sigma \textsc{arg}_2)$

$\lambda y.\lambda x.\lambda e.\mathit{select}(e) \wedge \mathit{agent}(e) = x \wedge \mathit{theme}(e) = y :$
$(\uparrow_\sigma \textsc{arg}_2) \multimap (\uparrow_\sigma \textsc{arg}_1) \multimap (\uparrow_\sigma \textsc{event}) \multimap \uparrow_\sigma$

The fourth and fifth lines of the lexical entry in (13) state that the s-structure of the SUBJ is associated with the s-structure attribute $\textsc{arg}_1$, and the s-structure of the OBJ is associated with the s-structure attribute $\textsc{arg}_2$. The final two lines contain the meaning constructor encoding the relevant semantic information: Asudeh and Giorgolo adopt a Neo-Davidsonian event semantics for their meaning language

(Chapter 8, Section 10) encoding information about thematic roles, treating them as functions from events to individuals. At semantic structure, Asudeh and Giorgolo distinguish the arguments of a predicate by means of attributes like $\textsc{arg}_1$ and $\textsc{arg}_2$ rather than the names of specific thematic roles such as AGENT and PATIENT for the relevant s-structure attributes, since the meaning constructor in the final line includes an encoding of these roles in the meaning language.

Given the lexical entry in (13), Asudeh and Giorgolo's f-structure and s-structure for *David selected Chris* is:

(14)

$$\begin{bmatrix} \text{PRED} & \text{`SELECT'} \\ \text{TENSE} & \text{PST} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`DAVID'} \end{bmatrix} \\ \text{OBJ} & \begin{bmatrix} \text{PRED} & \text{`CHRIS'} \end{bmatrix} \end{bmatrix} \xrightarrow{\sigma} \begin{bmatrix} \text{REL} & \text{SELECT} \\ \text{EVENT} & [\ ] \\ \text{ARG}_1 & [\ ] \\ \text{ARG}_2 & [\ ] \end{bmatrix}$$

According to Asudeh and Giorgolo's proposal, then, the relation between grammatical functions and semantic arguments is specified directly in the lexical entries of predicates, and there is no separate level of argument structure. Using this model, Asudeh and Giorgolo (2012) develop a detailed analysis of optional arguments, which we describe in Section 10.5.

A number of other theories of the nature and content of argument structure have also been proposed; Alsina (1996, Chapter 1) and Butt (2006, Chapter 5) provide a useful overview and summary. Spencer (2013, Chapter 7) provides a detailed discussion of argument structure as a level of representation distinct from syntax and semantics, containing only the aspects of the semantic representation that are relevant to the morphosyntax, and only those aspects of the functional syntax that are relevant to the semantics.

3. GRAMMATICAL FUNCTION ALTERNATIONS

A primary focus of LFG theory since its inception has been the relation between different syntactic realizations of a predicate and its arguments, and the characterization of grammatical function alternations such as the active/passive alternation and the dative alternation. LFG adheres to the *Principle of Direct Syntactic Encoding* (Kaplan and Bresnan 1982; Bresnan et al. 2016, 5.2), which states that syntactic operations may not alter the subcategorization requirements specified by a predicate.[3]

[3]Complex predicates raise a potential challenge for the Principle of Direct Syntactic Encoding; see Section 9 of this chapter.

(15) Principle of Direct Syntactic Encoding:

No rule of syntax may replace one function name by another. (Kaplan and Bresnan 1982, page 180)

All grammatical relation changes are lexical. (Bresnan et al. 2016, page 77)

Within the constraints imposed by the Principle of Direct Syntactic Encoding, there has been a steady evolution in the LFG view. In early formulations, alternations like the active/passive relation were characterized by *lexical rules* relating lexical entries corresponding to different diatheses of a verbal form. As Bresnan (1990) notes, however, the original theory of lexical rules did not provide a completely general picture of grammatical function alternations and their interactions or of the linking between grammatical functions and thematic roles, and the need for a more general theory subsequently became apparent. Since these early formulations, grammatical function alternations have been investigated in the context of *mapping* or *linking theory*, a theory of the mapping between thematic roles and grammatical functions. A number of different versions of mapping theory have been proposed. We discuss some of the more influential views in the following sections; Section 11 of this chapter contains a brief overview of other work on the subject.

3.1. Lexical Rules

Kaplan and Bresnan (1982) represent the relation between grammatical functions and thematic roles as a part of the semantic form value of the PRED feature, as discussed in Section 2. They treat different assignments of grammatical functions to the same thematic roles (as in, for example, the active and passive versions of a verb) by means of *lexical rules*, rules encoding a systematic relation between lexical entries for different forms of a predicate.

Early LFG treatments of lexical rules had a distinctly transformational character. Bresnan (1982c) proposes the following lexical rule for relating passive verbs to their active counterparts:

(16) $$\text{‘L}\langle \underset{\text{AGENT}}{\overset{\text{SUBJ}}{—}} \quad \underset{\text{THEME}}{\overset{\text{OBJ}}{—}} \rangle\text{’} \rightarrow \text{‘L}\langle \underset{\text{AGENT}}{\overset{\text{OBL}_{\text{AGENT}}/\emptyset}{—}} \quad \underset{\text{THEME}}{\overset{\text{SUBJ}}{—}} \rangle\text{’}$$

or in abbreviated form:

(17) $\text{SUBJ} \rightarrow \text{OBL}_{\text{AGENT}}$
$\text{OBJ} \rightarrow \text{SUBJ}$

This lexical rule was thought of as producing a lexical entry for the passive form of a predicate (with the AGENT argument realized as $\text{OBL}_{\text{AGENT}}$ and the THEME as SUBJ) on the basis of the lexical entry for the corresponding active form (with the AGENT argument realized as SUBJ and the THEME as OBJ). The fact that relation-changing lexical rules were formulated as operations on one lexical entry to produce another is telling of the transformationally oriented way in which these rules tended to be viewed in the early days of LFG: though the rules were formulated to apply to structures pairing thematic roles with grammatical functions, thematic roles did not usually play much of a role in regulating or constraining the rules. Instead, research focused primarily on the morphological and syntactic characteristics of grammatical function alternations rather than on a theory of the alignment of thematic roles with grammatical functions.

3.2. A Theory of Argument-Function Mapping

That there are regularities in the mapping between argument structure roles and grammatical functions has been clear since the pioneering work of Gruber (1965), Fillmore (1968), and especially Chomsky (1970); an early attempt to characterize these regularities was made by Ostler (1979), who proposed that the relation between argument structure roles and grammatical functions is given by a set of *linking rules*. Within LFG, Zaenen and Maling (1983) were among the first to propose a set of *Association Principles* relating grammatical functions to thematic roles. For example, they give the following Association Principles for Icelandic:

(18) Icelandic Association Principles (Zaenen and Maling 1983):

1. Agents are linked to SUBJ. (universal)
2. Casemarked Themes are assigned to the lowest available grammatical function. (specific to Icelandic)
3. If there is only one thematic role, it is assigned to SUBJ; if there are two, they are assigned to SUBJ and OBJ; if there are three, they are assigned to SUBJ, OBJ, and the secondary object function OBJ2. This principle applies after principle 2 and after the assignment of restricted grammatical functions.

Zaenen et al. (1985) provide further discussion of association principles for Icelandic, and also give a similar set of association principles for German; see also Rappaport (1983).

From this beginning, a vibrant body of research has developed. We only have room here to scratch the surface of the complex issues that are involved.

4. ARGUMENT CLASSIFICATION

In subsequent research on argument mapping, it was found that grammatical functions like SUBJ and OBJ can be grouped into natural classes, and generalizations about argument mapping can be expressed in terms of these classes rather than specific grammatical functions. This allows for thematic roles to be specified as associated with classes of grammatical functions. Levin (1986) was the first to propose such restrictions on the mapping between thematic roles and grammatical functions as:

(19) THEME is unrestricted.

As discussed in Chapter 2, Section 1.4, the (semantically) unrestricted functions are SUBJ and OBJ; these are the functions that can be filled by an argument with any thematic role, by an expletive or semantically empty argument, or by an argument of a raising verb (as discussed in Chapter 15). Levin's rule requires themes to be associated with either SUBJ or OBJ; more generally, on Levin's view, arguments with a particular thematic role can be linked to a class of grammatical functions such as the unrestricted functions, as in the case of her THEME rule.

Continuing the line of research forged by Zaenen and Maling (1983), Levin (1986) and others, Bresnan and Kanerva (1989) present a comprehensive theory of mapping from thematic roles to grammatical functions, referred to originally as *lexical mapping theory* (LMT), but later as simply *mapping theory*. Bresnan and Kanerva's theory has been further developed and refined by a number of authors, including Bresnan and Zaenen (1990), Zaenen (1993), Kibort (2001, 2004, 2006, 2007), and Bresnan et al. (2016). In the following, we base our presentation on Bresnan and Kanerva's influential proposal, together with some subsequent revisions and alternative proposals.[4]

4.1. Cross-Classification of Grammatical Features

Bresnan and Kanerva (1989) propose that the syntactic functions SUBJ, OBJ, OBJ_θ, and OBL_θ are decomposable into the feature specifications ±R(estricted) and ±O(bjective) in the following way:

(20) −R: semantically unrestricted functions SUBJ and OBJ; arguments with any thematic role (or with no thematic role) can fill these functions (see Chapter 2, Section 1.4).

+R: semantically restricted functions OBJ_θ and OBL_θ: only arguments bearing particular thematic roles can fill these functions. For example, only an argument with the role of AGENT can appear as an $\text{OBL}_{\text{AGENT}}$.

−O: nonobjective (non-object-like) functions SUBJ and OBL_θ.

+O: objective functions OBJ and OBJ_θ.

These features cross-classify the grammatical functions in this way:

(21)

	−R	+R
−O	SUBJ	OBL_θ
+O	OBJ	OBJ_θ

[4] Some authors, such as Alsina (1996), have developed approaches which diverge in more significant ways from Bresnan and Kanerva's original formulation; see Section 11.

4.2. Intrinsic and Default Classification of Thematic Roles

Bresnan and Kanerva (1989) assume that at argument structure, the arguments of a predicate are associated with thematic roles such as AGENT, GOAL, and THEME. The relation between argument roles and grammatical functions is expressed by associating the features ±R and ±O with thematic roles, given a theory of intrinsic and default classification principles. For example, Bresnan and Kanerva propose that arguments bearing the AGENT role are intrinsically classified thus:

(22) AGENT encoding:

$$\begin{array}{c}\text{AGENT}\\ | \\ [-\text{O}]\end{array}$$

This rule states that the AGENT argument must be a −O function: that is, the AGENT may not be associated with an objective or object-like function. Therefore, the AGENT role must be associated either with the SUBJ or the $\text{OBL}_{\text{AGENT}}$ function (one of the OBL_θ family of functions).

Turning next to the THEME or PATIENT thematic role, Bresnan and Kanerva propose the following classification, reminiscent of the THEME-linking rule in (19):

(23) THEME encoding:

$$\begin{array}{c}\text{THEME/PATIENT}\\ | \\ [-\text{R}]\end{array}$$

According to this classification, a THEME argument must be realized as an unrestricted function, either SUBJ or OBJ.

Bresnan and Kanerva classify locative arguments in the same way as AGENTS:

(24) LOCATIVE encoding:

$$\begin{array}{c}\text{LOCATIVE}\\ | \\ [-\text{O}]\end{array}$$

A LOCATIVE argument must therefore be linked to a nonobjective function, either SUBJ or OBL_{LOC}.

In addition to the intrinsic classifications, Bresnan and Kanerva (1989) propose a set of default assignments depending on the relative ranking of thematic roles on the thematic hierarchy. The thematic hierarchy which they assume is:

(25) Thematic hierarchy (Bresnan and Kanerva 1989):

AGENT > BENEFACTIVE > RECIPIENT/EXPERIENCER > INSTRUMENT > THEME/PATIENT > LOCATIVE

The thematic role of a predicate that is highest on the thematic hierarchy, also called the *logical subject*, is notationally represented as $\hat{\theta}$. By default, it is classified as unrestricted:

(26)

$$\begin{array}{c}\hat{\theta}\\ | \\ [-\text{R}]\end{array}$$

Other roles are classified as restricted:

(27) $\begin{array}{c} \theta \\ | \\ [+\textsc{r}] \end{array}$

These default classifications apply in every instance except when a conflict with intrinsic specifications would result.

4.3. Wellformedness Principles

Intrinsic and default classifications delimit the possible mappings between thematic roles and grammatical functions. Principles of wellformedness of the mapping relation further specify and constrain these associations, determining which particular grammatical function is associated with each role.

One such wellformedness principle is the *Subject Condition* (Chapter 2, Section 1.5), which holds in at least some languages; this principle requires each verbal predicate to have an argument associated with the SUBJ function. Another is the principle of Function-Argument Biuniqueness, originally proposed by Bresnan (1982d) (see also Bresnan and Kanerva 1989). In the following definition, $g_1 \ldots g_n$ is a list of grammatical functions, and $P(1 \ldots m)$ is a semantic form with a list of arguments $1 \ldots m$:

(28) Function-Argument Biuniqueness (Bresnan 1982d, page 163):

$G = g_1 \ldots g_n$ is a possible grammatical function assignment to $P(1 \ldots m)$ if and only if the mapping from $1 \ldots m$ to G defined by $i \mapsto g_i$ is injective (one-to-one and into).

This principle rules out a situation where the same grammatical function is associated with more than one thematic role, or where the same role is associated with more than one grammatical function.[5]

4.4. Other Proposals for Intrinsic Classification

Subsequent crosslinguistic research building on these foundations has explored alternative intrinsic classification principles applying in particular languages or groups of languages. Bresnan and Zaenen (1990) present an analysis of intransitive and resultative verbs that makes use of the standard ±R, ±O argument clas-

[5] The Function-Argument Biuniqueness principle has been challenged by Alsina (1995, 1996) in his analysis of reflexive and reciprocal constructions, where a single grammatical argument appears to fill two distinct thematic roles in relation to the predicate. Alsina's proposals are adopted by Miliĉević (2009). Reinhart and Siloni (2005) and Rákosi (2008) present alternative analyses of reflexive and reciprocal constructions which preserve the principle of Function-Argument Biuniqueness (see also Aranovich 2013). See Asudeh (2012, Chapter 5) for a discussion of Function-Argument Biuniqueness and its relation to the Theta Criterion (Chomsky 1981) and other theoretical principles governing the relation between thematic roles and grammatical functions. Argument Fusion in complex predicate formation also raises potential issues for Function-Argument Biuniqueness; see Section 9 of this chapter.

sifications, but eschews the use of default principles in argument mapping. On their view, thematic roles like AGENT and PATIENT are intrinsically associated with the ±R, ±O argument-classifying features, and further restrictions are imposed on the basis of how "patient-like" the argument role is. This provides an account of the *unergative/unaccusative distinction* (Perlmutter and Postal 1984): the subject of an unergative intransitive verb is agent-like, while the subject of an unaccusative intransitive verb is patient-like. Typical unergative verbs are *bark* and *run*, with agentive subjects; typical unaccusative verbs are *freeze* and *die*, with non-agentive, patient-like subjects. This difference in semantic role has syntactic consequences, in that unaccusative and unergative verbs exhibit different syntactic behavior in certain constructions: for example, unaccusative and unergative verbs in English differ in their behavior in constructions with resultative phrases. An unaccusative verb can appear with a resultative phrase, while an unergative verb cannot (*The river froze solid*/**The dog barked hoarse*); however, when a "fake reflexive" is added, unergative verbs but not unaccusative verbs can appear (*The dog barked itself hoarse*/**The river froze itself solid*). Section 10.1 provides additional discussion of the unergative/unaccusative distinction.

Zaenen (1993) presents an approach to argument mapping based on her theory of argument structure, discussed in Section 2, according to which arguments of a predicate are associated with certain semantically defined proto-agent and proto-patient properties. Zaenen proposes that the assignment of intrinsic feature classifications to an argument is based on whether the argument has a preponderance of proto-agent or proto-patient properties. Her analysis successfully accounts for the syntactic and semantic differences between two classes of unaccusative verbs in Dutch.

Her (2013), building on Her (2003), proposes that in accusative languages the only intrinsic classification of thematic roles is that PATIENT/THEME is classified as [−R], as in (23); there are no other intrinsic classifications. Her (2013) also argues that different intrinsic classifications are required to account for ergative languages, and Her and Deng (2012) claim that in Yami and other ergative languages there are no intrinsic classifications at all.

Bresnan et al. (2016) also assume a distinction between patient-like roles and other roles, compatible with a Proto-Role approach. They propose the following intrinsic classifications:[6]

[6]For an approach which makes a finer distinction between different sorts of patient-like roles, see Butt (1998).

(29) patient-like roles: $\begin{array}{c}\theta\\ |\\ [-\textsc{r}]\end{array}$

secondary patient-like roles: $\begin{array}{c}\theta\\ |\\ [+\textsc{o}]\end{array}$

other thematic roles: $\begin{array}{c}\theta\\ |\\ [-\textsc{o}]\end{array}$

Secondary patient-like roles include, for example, the second object argument in a ditransitive construction, though Bresnan et al. observe that the inventory of roles belonging to this category seems to be subject to crosslinguistic variation.

Most theories assuming intrinsic argument classifications analyze the AGENT argument as filling a nonobjective −O role, as shown in (22). However, Kroeger (1993) argues that in Tagalog, the AGENT can be syntactically realized as a non-subject term, or object. Manning (1996b) makes a similar argument for Greenlandic and other ergative languages. Arka (1998, 2003) and Arka and Simpson (2008) present analyses of the "objective voice" in Balinese which involve AGENT objects. Lødrup (1999b) discusses the Norwegian presentational focus construction, which also allows AGENT objects. He gives an Optimality-Theoretic analysis of Norwegian argument mapping that accounts for the differences between Norwegian and languages like English, which do not allow this possibility. Lødrup (2000) also analyzes Norwegian existential constructions as permitting AGENT objects.

4.5. The Markedness Hierarchy and Mapping Principles

Markedness principles underlying the association of thematic roles with grammatical functions have often been argued to play an important role in argument mapping. Bresnan and Moshi (1990) develop a theory of markedness principles which assumes that positive values for the R and O attributes are marked, meaning that the four major grammatical functions can be partially ordered in a markedness hierarchy (Bresnan and Moshi 1990, page 167):

(30) Markedness Hierarchy of Grammatical Functions (Bresnan and Moshi 1990):
$\textsc{subj} > \textsc{obj}, \textsc{obl}_\theta > \textsc{obj}_\theta$

SUBJ is the least marked grammatical function, since it has negative values for both R and O, while $\textsc{obj}_\theta$ is the most marked. Notably, this markedness hierarchy generalizes a segment of LFG's grammatical function hierarchy, given in (5) of Chapter 2. The recognition of distinct hierarchies for thematic roles and grammatical functions is important, as Falk (2006, pages 39–44) points out: while the same argument can be the most prominent with respect to both hierarchies, it is also possible for each hierarchy to have a different most prominent argument, resulting in a mismatch. Such a mismatch is exactly what is found, for example, in the passive construction (to be discussed in Section 6), where the argument ranked highest on the thematic hierarchy does not map to the most prominent argument on the grammatical function hierarchy.

The Markedness Hierarchy in (30) motivates a set of Mapping Principles for associating thematic roles with grammatical functions. The Mapping Principles in (31), from Bresnan et al. (2016, page 334), were originally proposed by Bresnan (2001c):

(31) a. Subject roles:

i. $\underset{[-\mathrm{o}]}{\hat{\theta}}$ is mapped onto SUBJ when initial in the a-structure;

ii. otherwise, $\underset{[-\mathrm{R}]}{\theta}$ is mapped onto SUBJ.

b. Other roles are mapped onto the lowest compatible function on the Markedness Hierarchy (30).

According to rule (31a.i), if the highest thematic role $\hat{\theta}$ is associated with the feature [−o], it is mapped onto SUBJ;[7] if this rule does not apply, rule (31a.ii) states that any argument associated with the feature [−R] is mapped to SUBJ. Rule (31b) defines mapping rules for the remaining thematic roles to grammatical functions other than SUBJ.

Both the Markedness Hierarchy and the Mapping Principles have been subject to revision as mapping theory continues to develop. Kibort (2001, 2004, 2006, 2007) argues for a simplified reformulation of the Mapping Principles in (31) into a single Mapping Principle. (What we refer to as argument positions are termed *ordered arguments* by Kibort.)

(32) Mapping Principle (Kibort 2001, 2004, 2006, 2007):
The ordered arguments are mapped onto the highest (i.e. *least* marked) compatible function on the Markedness Hierarchy.

Kibort argues that this reformulation achieves the correct mappings for various classes of predicates discussed in the literature, but avoids redundancy by depending upon the partial ordering of the Markedness Hierarchy. According to this formulation (and in contrast to Bresnan et al.'s formulation), the Subject Condition (Chapter 2, Section 1.5) is not necessary: this is because the requirement for most predicates to have a subject is ensured by the Mapping Principle, while impersonal predicates in many languages do not require subjects.

[7] Following Zaenen and Engdahl (1994), Bresnan et al. (2016) assume that semantically empty arguments of verbs like *rain* or *seem* also appear in the argument structure and are eligible for linking to a grammatical function. Semantically empty arguments can appear to the left of the highest thematic role $\hat{\theta}$; this accounts for the additional restriction in (31a.i), which applies only when the highest thematic role $\hat{\theta}$ is initial in the a-structure. If a semantically empty argument appears to the left of $\hat{\theta}$, the linking rule in (31a.i) does not apply.

Her (2013) proposes a revision of both the Markedness Hierarchy and the Mapping Principles (see also Her 2009). Her proposes that [−R] is less marked than [−O], with the result that the Markedness Hierarchy is fully ordered:

(33) Markedness Hierarchy of Syntactic Functions (Her 2013):
SUBJ > OBJ > OBL_θ > OBJ_θ

Her (2013) also proposes a "Unified Mapping Principle" (see also Her 1998, 2003, 2010; Her and Deng 2012) which is very similar to the Mapping Principle of Kibort:

(34) Unified Mapping Principle (Her 2013):
Map each a-structure role that is *available* onto the highest function that is *compatible* and *available*.

- A role θ is *available* for mapping if all roles to the left of θ are mapped; a function F is *available* for mapping to θ if F is not fully specified for by another role and also not linked to a role to the left of θ.
- A function is *compatible* if it contains no conflicting feature.

Under this definition, as with Kibort's proposal, the Function-Argument Biuniqueness constraint and the Subject Condition are no longer required as independent constraints, since they are effectively incorporated into the definition of the Mapping Principle. Due to Her's views regarding intrinsic classifications (mentioned in the previous section), the details of how this Unified Mapping Principle applies are slightly different from the application of Kibort's Mapping Principle, but both appear equally capable of accounting for attested patterns of linking between thematic roles and grammatical functions.

5. SELECTION AND CLASSIFICATION: SYNTACTIC OR SEMANTIC?

As described in Section 1 of this chapter, the earliest representations of argument structure in LFG implicitly or explicitly dissociate argument positions and thematic roles (as in example 6 on page 345). In contrast, the mapping theory developed by Bresnan and Kanerva (1989) and Bresnan and Zaenen (1990) effectively involves a fusion of argument positions with thematic roles. Kibort (2007) discusses this development, providing the following quote from Bresnan and Zaenen (1990, page 48):

> The grammatically significant participant-role relations in the structure of events are represented by a-structures. An a-structure consists of a predicator with its argument roles, an ordering that represents the relative prominence of the roles, and a syntactic classification of each role indicated by a feature.

On this view, the a-structure for a verb like English *select* is represented as in (35). The verb subcategorizes for two arguments, labeled according to their thematic role. These roles each have an intrinsic classification, as discussed in Section 4.2, and these classifications, together with default and construction-specific classifications, constrain the grammatical functions of these roles at f-structure.

(35)

	select	⟨	AGENT	PATIENT	⟩
			|	|	
intrinsic:			[−O]	[−R]	

In this model, the arguments of a predicate are defined by thematic role, and argument position plays no role. However, a number of authors including Mohanan (1994, pages 15ff.), Joshi (1993), Alsina (1996, page 37) and Ackerman and Moore (2001, pages 40ff.) have argued for the earlier view, that it is necessary to separate argument positions from thematic roles.

Kibort (2007) observes that some predicates show variation in the assignment of thematic roles to grammatical functions, and argues that these patterns are best analyzed by appeal to argument position rather than thematic role. Verbs exhibiting the *spray/load* alternation are examples of such predicates: in terms of argument positions, both variants are three-place predicates selecting for a SUBJ, OBJ, and OBL_θ, but the two non-AGENT thematic roles can associate with either the second or third argument position.[8]

(36) a. *David sprayed* *(the) paint* *onto the wall.*
SUBJ OBJ OBL_θ

b. *David sprayed* *the wall* *with paint.*
SUBJ OBJ OBL_θ

Kibort also observes that morphosyntactic operations can make reference to argument structure positions independent of thematic roles. For example, passivization and locative inversion can be described as lexical operations affecting the first argument position of a verb, but there is no way to generalize over the particular thematic role which that first argument may have. On the basis of such evidence, Kibort (2007) concludes that argument positions must be separated from thematic roles, and represents the former using labels such as arg_1, arg_2, and so on.[9]

Kibort proposes that a single 'valency template' is available to non-derived predicates in all languages. Following Zaenen (1993), Ackerman and Moore

[8]The *spray/load* alternation is discussed by Ackerman (1990, 1992), Levin (1993, Chapter 2), and Ackerman and Moore (2001). Similar alternations including verbs such as 'present' in Hungarian are analyzed in mapping theory terms by Ackerman (1992) and Laczkó (2013).

[9]Note that Kibort's use of labels like arg_1, arg_2, etc. is not the same as in Asudeh and Giorgolo's model, described in Section 2, where ARG_1 and ARG_2 represent s-structure attributes whose values are s-structures. We distinguish between the two typographically by using small capital letters for Asudeh and Giorgolo's s-structure attributes, and lower case letters for Kibort's argument structure labels.

(2001), and others, Kibort proposes that a fixed total ordering exists within this valency template:[10]

(37)
$$\begin{array}{llllll} \langle\ \text{arg}_1 & \text{arg}_2 & \text{arg}_3 & \text{arg}_4 & \ldots & \text{arg}_n\ \rangle \\ [-\text{O}/-\text{R}] & [-\text{R}] & [+\text{O}] & [-\text{O}] & & [-\text{O}] \end{array}$$

Every predicate selects for one or more arguments from this template. The slots which a particular predicate selects are lexically specified, and it is possible for one or more of the argument positions to be skipped. Notice that while this template broadly corresponds to the hierarchy of syntactic functions (SUBJ > OBJ > OBJ_θ > OBL_θ), it is defined in terms of the features [±O] and [±R]. The thematic roles entailed by a particular predicate are associated with argument positions partly on the basis of intrinsic associations between roles and [±O]/[±R] classifications (such as the association of agentive roles with [−O] in many languages), but there is no sense in which a particular thematic role is inherently associated with a particular argument position. Kibort (2007) also recognizes the influence of a hierarchical ordering of thematic roles but, following Levin and Rappaport Hovav (2005, Chapter 6), points out that no thematic hierarchy can be defined that captures all generalizations over the association of argument positions with thematic roles. Thematic roles may therefore be understood to be ordered, but this ordering is only default, and different actual orderings are possible: under certain conditions roles may map to slots in different ways, as for example in the *spray*/*load* alternation shown in (36). We agree with Kibort that a separation should be maintained between thematic roles and argument positions, and adopt her approach to argument structure in the following four sections. We examine some of the central phenomena which have been the focus of attention in mapping theory, providing an argument structure analysis based on Kibort's proposals.

6. THE ACTIVE/PASSIVE ALTERNATION

As a first illustration of the theory, we consider the active and passive versions of a verb like *select* in examples such as:

(38) a. *David selected Chris.*

b. *Chris was selected by David.*

The intrinsic meaning of the verb *select* involves a selector and a selectee, or an AGENT and THEME argument. As a canonical transitive verb in English, its subcategorization frame includes arg_1 and arg_2, the first two argument positions in the universal valency template presented in (37) on page 361; the AGENT is associated with arg_1, and the THEME is associated with arg_2.

[10] Kibort's analysis of arg_1 as either −O or −R is designed to account for the distinction between unergative and unaccusative verbs; see Section 10.1.

(39)

$$\begin{array}{llcccl} & & \text{AGENT} & \text{THEME} & \\ & & | & | & \\ \textit{select} & \langle & \text{arg}_1 & \text{arg}_2 & \rangle \end{array}$$

These argument positions are intrinsically associated with mapping feature specifications:

(40)

$$\begin{array}{llccl} \textit{select} & \langle & \text{arg}_1 & \text{arg}_2 & \rangle \\ & & [-\text{o}] & [-\text{r}] & \end{array}$$

We now apply the Mapping Principle (example 32 on page 358). The highest, least marked function on the Markedness Hierarchy is SUBJ. Since arg_1 is specified as [−o], assignment to SUBJ is compatible with its specifications, and it is mapped to SUBJ. Of the remaining core functions, only OBJ is compatible with the [−r] specification of arg_2, so arg_2 is associated with OBJ. We therefore have the following associations, where M.P. stands for Mapping Principle:

(41)

$$\begin{array}{lllccl} & & & \text{AGENT} & \text{THEME} & \\ & & & | & | & \\ & \textit{select} & \langle & \text{arg}_1 & \text{arg}_2 & \rangle \\ & & & [-\text{o}] & [-\text{r}] & \\ \hline \text{M.P.} & & & \text{SUBJ} & \text{OBJ} & \end{array}$$

Thus, the theory correctly captures the fact that in the active voice, the AGENT argument of *select* is the SUBJ, and the PATIENT is the OBJ:

(42) *David selected Chris.*

$$\begin{bmatrix} \text{PRED} & \text{‘SELECT}\langle\text{SUBJ,OBJ}\rangle\text{’} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{‘DAVID’} \end{bmatrix} \\ \text{OBJ} & \begin{bmatrix} \text{PRED} & \text{‘CHRIS’} \end{bmatrix} \end{bmatrix}$$

We now examine the passive counterpart of this active sentence. Most work within LFG, following Bresnan and Moshi (1990), assumes an account of the passive in which the thematically highest argument is suppressed and, therefore, unavailable for linking. For example, under this approach, the passive of *select* has this argument structure:

(43) Suppression-based account of the passive (Bresnan and Moshi 1990),:

$$\begin{array}{llccl} & & \text{AGENT} & \text{THEME} & \\ & & | & | & \\ \textit{select} & \langle & \text{arg}_1 & \text{arg}_2 & \rangle \\ & & [-\text{o}] & [-\text{r}] & \\ & & | & & \\ & & \emptyset & & \end{array}$$

Under these assumptions, only the second argument slot is available for linking to a grammatical function. Since [−r] is compatible with the highest function on the Markedness Hierarchy, arg_2 maps to SUBJ. This can be thought of as a promotion of arg_2 from OBJ, as in (41), to SUBJ.

(44) Suppression-based account of the passive:

$$\begin{array}{lccccc} & & & \text{AGENT} & \text{THEME} & \\ & & & | & | & \\ & \textit{select} & \langle & \text{arg}_1 & \text{arg}_2 & \rangle \\ & & & [-\text{o}] & [-\text{r}] & \\ & & & | & & \\ & & & \emptyset & & \\ \hline \text{M.P.} & & & & \text{SUBJ} & \end{array}$$

By contrast, Kibort (2007) argues for a rather different account of the passive. In her view, morphosyntactic operations such as voice alternations do not affect the selection of argument positions by a predicate, nor the alignment of argument positions with thematic roles; passivization and similar morphosyntactic operations affect only the mapping between grammatical functions and argument positions. Given the Markedness Hierarchy and the Mapping Principle, there is only one way in which this mapping can be changed: by augmenting (and thus further restricting) the classification of argument positions prior to the application of the Mapping Principle. Only the addition of positive specifications, i.e. [+R] or [+O], counts as increasing markedness. Kibort refers to this as a "mechanism of increasing markedness". There are a limited number of logical possibilities for the addition of further specifications to argument positions: a [−R] position can be additionally specified as [+O], a [−O] position can be additionally specified as [+R], or a [+O] position can be additionally specified as [+R]. It is not possible for a [−R] position to be specified as [+R], or for a [−O] position to be specified as [+O], since an argument position may have only one value for each of these features; in addition, there is no argument position prespecified as [+R].

Under Kibort's analysis, then, passive voice is the result of adding a [+R] specification to the first argument position of a predicate pre-specified as [−O]. This means that the first argument position of a passive predicate (arg_1) can associate only with the oblique grammatical function OBL_θ, while the second argument position (arg_2), if present, is necessarily associated with the SUBJ function. We therefore have the following argument structure for *select* in the passive voice:

(45) Demotion-based account of the passive (Kibort 2007):

$$\begin{array}{lccccc} & & & \text{AGENT} & \text{THEME} & \\ & & & | & | & \\ & \textit{select} & \langle & \text{arg}_1 & \text{arg}_2 & \rangle \\ & & & [-\text{o}] & [-\text{r}] & \\ \text{passive:} & & & \mathbf{[+r]} & & \\ \hline \text{M.P.} & & & \text{OBL}_\theta & \text{SUBJ} & \end{array}$$

This produces the correct result, namely that the THEME argument of passive *select* is the SUBJ, as in this f-structure:

(46) *Chris was selected by David.*

$$\begin{bmatrix} \text{PRED} & \text{`SELECT}\langle\text{SUBJ,OBL}_{\text{AGENT}}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`CHRIS'} \end{bmatrix} \\ \text{OBL}_{\text{AGENT}} & \begin{bmatrix} \text{PRED} & \text{`DAVID'} \end{bmatrix} \end{bmatrix}$$

Kibort (2001; 2004, in particular pages 360–363) provides detailed argumentation for this demotional approach to the passive. One significant difference between this and the suppression-based, promotional account of Bresnan and Moshi (1990) is in the status of the AGENT argument. Under Bresnan and Moshi's approach to passivization, the AGENT may be expressed only as a modifying adjunct, not as an oblique argument of the verb, since its suppression leaves it unavailable for linking to OBL_θ. Under Kibort's analysis, the converse is true: the AGENT argument is explicitly mapped to OBL_θ, and so cannot be expressed as an adjunct.[11]

Kibort (2012) draws out an interesting contrast between the passive and an apparently similar operation, the anticausative, exemplified in the following two pairs of English and Polish sentences:

(47) a. *I spilled the soup.*

b. *The soup spilled.*

(48) a. *Tomek wylał zupę.*
Tomek.NOM spilled.3SG.M soup.ACC
'Tomek spilled the/some soup.'

b. *Zupa wylała się.*
soup.NOM spilled.3SG.F REFL
'The soup spilled.'

Kibort argues that voice alternations are meaning preserving, while the anticausative is not meaning preserving. In the anticausative, an event affecting a patient/theme is expressed without the cause of the event being specified. Morphosyntactic operations are necessarily meaning preserving; therefore, the anticausative alternation cannot be morphosyntactic, but must be accounted for in lexical terms. Kibort (2012) consequently argues that two distinct lexical entries must be assumed for verbs that display the anticausative alternation:

(49)

			AGENT	PATIENT/THEME	
	(trans) *spill*	$\langle$	arg_1	arg_2	$\rangle$
			[−O]	[−R]	
M.P.			SUBJ	OBJ	

[11] Within the context of their own approach to argument structure (as described in Section 5 and discussed further in Section 10.5), Asudeh and Giorgolo (2012) treat the oblique agent as an OBL_θ, but state that their model could easily be reformulated to treat it as an ADJ.

(50)

		AGENT	PATIENT/THEME	
	(anticaus) *spill*	⟨	arg_2 [−R]	⟩
M.P.			SUBJ	

In both cases the verb entails a spiller AGENT and a spillee PATIENT/THEME, but in the anticausative variant there is no argument position with which the AGENT can be associated. If it is expressed, it must be expressed as an adjunct. Thus, even though the anticausative alternation may initially appear to be very similar to the passive, Kibort (2012) analyzes the two as being quite different in argument structure terms.

7. IMPERSONAL PREDICATION

In English, the passive alternation is restricted to predicates with more than one argument. In some languages, however, intransitive predicates may undergo passivization: this may result in an impersonal construction which violates the Subject Condition, as discussed in Chapter 2, Section 1.5. The account of passivization proposed by Kibort accounts equally well for such impersonal passives. Kibort (2006, example 55) provides the following sentence, which illustrates a passive use of the Polish intransitive verb *palić* 'smoke'.

(51) *Wchodzisz i czujesz, że było palone.*
come.in.2SG and smell.2SG that was.3SG.N smoke.PTCP.SG.N
'You come in and you can smell that there has been smoking (here).'

Active forms of this verb have the following argument structure, with the AGENT of the verb realized as its SUBJ:

(52)

		AGENT	
	palić 'smoke' ⟨	arg_1 [−O]	⟩
M.P.		SUBJ	

In the passive, Kibort analyzes the first argument position as being additionally classified [+R]; it must therefore map to OBL_θ. Since there is only one argument position, and this position maps to OBL_θ, the passive of an intransitive verb does not have a SUBJ argument, in violation of the Subject Condition.[12]

[12]Impersonal constructions are not necessarily uniform in this respect; see, for example, German impersonal passives as analyzed by Berman (2003), outlined in Chapter 2, Section 1.5.

(53)

$$\begin{array}{rlcl} & & \text{AGENT} & \\ & & | & \\ & \textit{palić}\ \text{'smoke'}\ \langle & \text{arg}_1 & \rangle \\ & & [-\text{o}] & \\ \text{passive:} & & [+\text{r}] & \\ \hline \text{M.P.} & & \text{OBL}_\theta & \end{array}$$

Inherently impersonal predicates like English *rain* can also be analyzed under this model:

(54)

$$\begin{array}{rlcl} & \textit{rain}\ \langle & \text{arg}_1 & \rangle \\ & & [-\text{o}] & \\ \hline \text{M.P.} & & \text{SUBJ} & \end{array}$$

This gives the following f-structure:

(55) *It rained.*

$$\begin{bmatrix} \text{PRED} & \text{'RAIN}\langle\ \rangle\ \text{SUBJ'} \\ \text{SUBJ} & \begin{bmatrix} \text{FORM} & \text{IT} \end{bmatrix} \end{bmatrix}$$

The difference between an inherently impersonal predicate like *rain* and other intransitive verbs, such as the one shown in (52), is that *rain* does not entail any participants, as (55) shows, i.e. it is not associated with any thematic role.[13] Thus, arg_1 appears in the subcategorization frame for *rain*, and maps to a grammatical function, but there is no thematic role with which it is associated.

Other work on impersonal constructions and expletives within the LFG framework includes Berman (2003, Chapters 4 and 8) on expletive subjects in German; Maling and Sigurjónsdóttir (2013) on impersonal passive constructions in Icelandic; Kelling (2006) on personal and impersonal passive constructions in Spanish; Rubio Vallejo (2011), also on impersonal constructions in Spanish; Lødrup (2000) on existential constructions in Norwegian; and Kibort and Maling (2015) on the distinction between active and passive impersonal constructions.

8. LOCATIVE INVERSION

The locative inversion construction is analyzed in detail by Bresnan and Kanerva (1989) (see also Bresnan 1994) in an exploration of the effect of other levels of linguistic structure on mapping principles. The locative inversion construction is a particularly fruitful arena for such study, since locative inversion involves the interaction of a particular information structural property — presentational focus — with mapping principles.

[13] For more on intransitive verbs and argument structure, see Section 10.1.

Bresnan and Kanerva (1989) examine argument structure alternations with verbs like Chicheŵa *-im-* 'stand'. Example (56) illustrates the uninverted construction, with a THEME subject and a LOCATIVE oblique argument:[14]

(56)

Nkhandwe	*y-a-im-a*	*pa-m-chenga.*
9.fox	9SUBJ-PRF-stand-IND	16-3-sand

'The fox is standing on the sand.'

Example (57), with a preposed LOCATIVE and a focused THEME argument, illustrates the locative inversion construction:

(57)

Pa-m-chenga	*p-a-im-a*	*nkhandwe.*
16-3-sand	16SUBJ-PRF-stand-IND	9.fox

'On the sand is standing the fox.'

In the locative inversion construction, as Bresnan and Kanerva (1989) demonstrate, the noun phrase *nkhandwe* 'fox' bears the OBJ relation, while the locative phrase *pa-m-chenga* 'on the sand' bears the SUBJ relation. Evidence for this comes from patterns of verb agreement: in (56), the verb agrees in noun class with the subject *nkhandwe* 'fox', which is class 9, whereas in (57), the verb shows class 16 agreement with the locative subject *pa-m-chenga* 'on the sand'. Additionally, Bresnan and Kanerva describe syntactic restrictions on nonfinite verb phrase modifiers, which may not appear with an overt subject. In verb phrase modifiers involving locative inversion, it is the locative subject that must be nonovert:

(58)

m-nkhalangó	*[m-ó-khál-á*	*mi-ângo]*$_{\mathrm{VP}}$
18-9-forest	18SUBJ-INF-live-IND	4-lion

'in the forest where there live lions'

Constructions involving subject raising in Chicheŵa also provide evidence that the LOCATIVE phrase is the subject and the THEME phrase is the object in examples like (57); see Bresnan and Kanerva (1989) for discussion.

Under Kibort's (2007) analysis, uninverted examples such as (56) can be analyzed as involving verbs which select for arg_1 and arg_4, that is:

(59)

$$\begin{array}{llcccc}
 & & & \textsc{theme} & \textsc{locative} & \\
 & & & | & | & \\
 & \textit{-im-}\text{ 'stand'} & \langle & \mathrm{arg}_1 & \mathrm{arg}_4 & \rangle \\
 & & & [-\textsc{r}] & [-\mathrm{o}] & \\
\hline
\text{M.P.} & & & \textsc{subj} & \textsc{obl}_\theta &
\end{array}$$

Once again, the mapping from argument positions to grammatical functions derives without difficulty from the Mapping Principle. In thematic terms, this verb entails the existence of a stander and a location of standing, or a THEME and a LOCATIVE, and these associate with the argument positions as shown, in accordance with the thematic hierarchy.

[14]Numbers in the glosses indicate the noun class of the arguments.

Kibort treats locative inversion as a morphosyntactic operation which involves adding the classification [+O] to the first argument of a verb pre-specified as [−R], restricting it further so that arg_1 must map to OBJ. According to the Mapping Principle, arg_4, which is intrinsically associated with the classification [−O], maps to SUBJ in the inverted construction.[15] The inverted construction is therefore analyzed in the following way:

(60)

			THEME	LOCATIVE	
	-*im*- 'stand'	⟨	arg_1	arg_4	⟩
			[−R]	[−O]	
loc. inv.:			**[+O]**		
M.P.			OBJ	SUBJ	

Morimoto (1999) proposes an alternative, Optimality-Theoretic account of argument mapping in locative inversion and related constructions.

9. COMPLEX PREDICATES AND ARGUMENT LINKING

In early LFG work on argument structure, it was often assumed that argument linking is a process applying to individual words in the lexicon. Butt (1995) and Alsina (1996) challenge this view by providing evidence that syntactic structures which are monoclausal at f-structure can be associated with constructions consisting of more than one (potentially nonadjacent) word.

Butt (1995) discusses the permissive construction in Urdu, illustrated in (61):

(61)

Anjum-ne	*Saddaf-ko*	*ciṭṭhii*	*likh-ne*	*d-ii*
Anjum-ERG	Saddaf-DAT	note.NOM.F.SG	write.INF.OBL	let-PRF.F.SG

'Anjum let Saddaf write a note.'

The permissive construction consists of two verbs, the main verb (here *likhne* 'write') and the light, auxiliary-like verb *de* (here *dii*) 'let'. Butt shows that at the level of c-structure, the permissive construction involves either a V′ constituent containing the main and light verbs (62a), or a VP constituent containing the main verb and the OBJ argument (62b,c):

(62) a.

Anjum-ne	*Saddaf-ko*	*ciṭṭhii*	*[likh-ne*	*d-ii]*$_{\text{V}'}$
Anjum-ERG	Saddaf-DAT	note.NOM.F.SG	write-INF.OBL	let-PRF.F.SG

b.

Anjum-ne	*d-ii*	*Saddaf-ko*	*[ciṭṭhii*	*likh-ne]*$_{\text{VP}}$
Anjum-ERG	let-PRF.F.SG	Saddaf-DAT	note.NOM.F.SG	write-INF.OBL

[15]This explanation for argument linking in locative inversion is distinct from the earlier proposal of Bresnan and Kanerva (1989), according to which the inverted construction requires a locative argument intrinsically specified as [−R]. On their analysis, the locative argument is further classified [−O], and so must map to SUBJ, leaving the theme argument to map to OBJ.

c. *Anjum-ne [ciṭṭhii likh-ne]*$_{\text{VP}}$ *Saddaf-ko d-ii*
Anjum-ERG note.NOM.F.SG write-INF.OBL Saddaf-DAT let-PRF.F.SG
'Anjum let Saddaf write a note.'

Although the main verb/light verb combination need not form a c-structure constituent, and in fact the verbs need not appear adjacent to each other, Butt (1995) shows that the permissive construction is monoclausal at f-structure, involving a single *complex predicate* constructed from the two verbal forms. Evidence for this comes from verb agreement patterns in Urdu. The Urdu verb agrees with the nominative argument that is highest on the grammatical function hierarchy; if none of its arguments are nominative, the verb shows default (third person masculine singular) agreement. In (61), we see that the light verb *dii* 'let' agrees with the nominative feminine singular noun *ciṭṭhii* 'note'. This shows that *ciṭṭhi* 'note' is a syntactic argument of the main predicate — one which must include *dii* — since agreement is possible only between a predicate and one of its syntactic arguments. Butt provides further evidence from constructions involving control and anaphora that points to the same conclusion: the verbs *likhne* 'write' and *dii* 'let' combine to form a single syntactic predicate at f-structure, taking a single array of syntactic arguments.

As Butt's work makes clear, complex predicate formation — and, therefore, argument linking — cannot be defined by reference to the argument roles of a single word or even a single phrase structure constituent; data discussed by Alsina (1996) point to a similar conclusion. As mentioned above, the theory of argument linking developed by Bresnan and Kanerva (1989) was originally referred to as *lexical* mapping theory, but the work of Butt and Alsina, together with other research, led to the relabeling of the theory as *functional* mapping theory or simply *mapping theory*, in acknowledgement of the fact that the theory cannot apply exclusively to individual words.

9.1. Case Study: Complex Predicates in Urdu

The analysis of complex predicates in Urdu has been the topic of continuing research in LFG.[16] In the rest of this section, we will illustrate the theory of argument structure and mapping theory in relation to complex predicates using examples from Urdu, before moving on to consider work on complex predicates in other languages in Section 9.2.

Based on work by Alsina and Joshi (1991) and Butt (1998), Butt (2014a) distinguishes two types of causative complex predicates, depending on the type of argument merger that takes place between the light verb and the lexical verb. She discusses Urdu permissive constructions, distinguishing the type introduced in the previous section, which she labels the 'allow-to-do' permissive (example 61, repeated as 63), from the 'allow-to-happen' permissive (example 64).

[16] In addition to the works cited, complex predicates in Urdu have been discussed by Butt and Geuder (2001), Butt and Ramchand (2005), Ahmed and Butt (2011), Raza (2011), Ahmed et al. (2012), Butt et al. (2012), Sulger (2012), and Lowe (2015a).

(63) *Anjum-ne Saddaf-ko ciṭ̤ṭhii likh-ne d-ii*
Anjum-ERG Saddaf-DAT note.NOM.F.SG write-INF.OBL let-PRF.F.SG
'Anjum let Saddaf write a note.'

(64) *kacce lamhe-ko ʃaak=par pak-ne*
unripe.M.OBL moment.M.SG.OBL-ACC branch.M.SG=on ripen-INF.OBL
d-o
give-IMP
'Let the tender moment ripen on the bough.'

In the 'allow-to-do' permissive in (63), argument merger between the two parts of the complex predicate involves what Butt (2014a) calls 'Argument Fusion': an argument of the lexical predicate *likh* 'write' (here the participial form *likhne*) is coindexed with an argument of the light verb predicate *di*. In this construction, the highest argument of the lexical predicate is coindexed with the lowest argument of the light verb predicate.

The argument structure for the verb *likh* 'write' is shown in (65); (66) illustrates the use of this verb on its own, as the only verb in the clause.

(65)

			AGENT	THEME	
			|	|	
	likh 'write'	⟨	arg_1	arg_2	⟩
			[−o]	[−r]	
M.P.			SUBJ	OBJ	

(66) *Saddaf-ne ciṭ̤ṭhii likh-ii*
Saddaf-ERG note.NOM.F.SG write.PRF.F.SG
'Saddaf wrote a note.'

The subcategorization frame for the 'allow-to-do' permissive verb *de* 'let' (*dii* in 63) can be represented as:

(67) 'allow-to-do' *de*: 'let⟨arg_1, arg_3, %PRED⟩'

Here '%PRED' in the argument structure for *de* indicates that this verb, in its use as a permissive light verb, is incomplete in terms of its subcategorization frame: it requires another predicate's argument structure with which to merge. The argument structure merger of these predicates involves the coindexation of the lowest argument of the matrix predicate *de* 'let', in this case arg_3, with the highest argument of the embedded predicate *likh* 'write', in this case (and usually) arg_1. This results in the following merged argument structure:

(68)

	de 'let'	⟨	arg_1	arg_3	'write'	⟨	arg_1	arg_2	⟩⟩
			[−o]	[+o]			([−o])	[−r]	
M.P.			SUBJ	OBJ_θ				OBJ	

The coindexed arguments are treated as a single argument for the purposes of mapping theory: they must be linked to a single grammatical function. Mapping proceeds entirely in accordance with the Mapping Principle, but it must proceed according to the hierarchy of arguments as denoted by their indices, and not simply left-to-right. In this example, the arg_2 of the merged predicate is 'to the right' of the arg_3, but according to the hierarchy represented by their indices, it is arg_2, and so must be mapped first. If arg_3 were mapped before arg_2, it would be mapped to the highest available [+o] argument, which would be OBJ. But with SUBJ already linked to arg_1, there would then be no [−R] argument available for arg_2 to map to. If arg_2 is mapped first, it is mapped to OBJ, and subsequently arg_3 is mapped to OBJ_θ. Note that the properties of the fused argument (arg_3 of 'let' fused with arg_1 of 'write') derive entirely from the arg_3 of the matrix predicate, and not from the arg_1 of the embedded predicate: the fused argument maps to OBJ_θ, even though this is not compatible with the [−o] classification of the embedded arg_1 (hence it is presented in parentheses).

Butt (2014a) contrasts Argument Fusion with the distinct Argument Raising construction, which is found with the 'allow-to-happen' permissive in Urdu. Butt argues that the 'allow-to-happen' construction, shown in (64), involves a different subcategorization frame for the light verb *de* 'let':

(69) 'allow-to-happen' *de*: 'let⟨arg_1, %PRED⟩'

The two distinct subcategorization frames of *de* 'let' are associated with different kinds of argument merger: the subcategorization frame in (67) is associated with Argument Fusion, while the subcategorization frame in (69) is associated with Argument Raising. Argument Raising involves the merger of two argument domains without any coindexation. Thus, the merged argument structure for the 'allow-to-happen' complex predicate in (64) is:

(70)

de 'let'	⟨	arg_1	'ripen'	⟨	arg_1	⟩⟩
		[−o]			[−R]	
M.P.		SUBJ			OBJ	

In this type of argument merger, the argument structure for the embedded predicate, here *pak* 'ripen', is simply inserted into the slot of the light verb's argument structure, with no coindexation between (or fusion of) the arguments. Mapping then proceeds entirely in accordance with the Mapping Principle; since both arguments have the same index (i.e. both are arg_1), the order of mapping proceeds by left-to-right precedence. That is, the leftmost arg_1 must map first, followed by the embedded arg_1.

As shown in detail by Butt et al. (2010), complex predicates in Urdu can be recursively embedded, and when this happens we find recursive argument merger. There are many different light verbs in Urdu besides *de* 'let' which form complex predicates. One of these is *le* 'take'; this is an aspectual light verb, which adds perfectivity, or a sense of completion, to the event described by the predicate:[17]

[17] The precise semantic contribution of the light verb and how this might be accounted for is discussed in Butt and Tantos (2004). Butt and Tantos consider the use of Petri Nets (Peterson 1981) for the representation of lexical meaning in LFG with particular reference to complex predicates.

(71) *Saddaf-ne ciṭṭhii likh l-ii*
Saddaf-ERG note.NOM.F.SG write take.PRF.F.SG
'Saddaf wrote a note (completely).'

The subcategorization frame for the light verb *le* 'take' is shown in (72); the argument structure for the complex predicate *likh lii* 'wrote (completely)', which involves Argument Fusion, is shown in (73).

(72) *le*: 'take' ⟨ arg$_1$, %PRED ⟩

(73)

'take'	⟨	arg$_1$	'write'	⟨	arg$_1$	arg$_2$	⟩⟩
		[−o]			([−o])	[−r]	
		SUBJ				OBJ	

This aspectual complex predicate can be embedded as the predicate argument of the permissive 'allow-to-do' light verb *de* shown in (67):

(74) *Anjum-ne Saddaf-ko ciṭṭhii likh le-ne d-ii*
Anjum-ERG Saddaf-DAT note.NOM.F.SG write take-INF.OBL let-PRF.F.SG
'Anjum let Saddaf write a note (completely).'

As with complex predicates that show only one level of embedding, this predicate is a true complex predicate: it is monoclausal at f-structure. The argument structure for this complex predicate, which involves multiple instances of Argument Fusion, combining (65) with (67) and (72), is:

(75)

'let'	⟨ arg$_1$	arg$_3$	'take'	⟨ arg$_1$	'write'	⟨ arg$_1$	arg$_2$ ⟩⟩⟩
	[−o]	[+o]		([−o])		([−o])	[−r]
	SUBJ	OBJ$_\theta$					OBJ

As one would expect, this complex predicate can be further embedded under other light verbs; Butt et al. (2010) provide detailed discussion of this recursive embedding.

An alternative line of analysis regarding complex predicates involves the use of the *restriction operator* (Chapter 6, Section 9.4). Kaplan and Wedekind (1993) propose a very different analysis of complex predicates in Urdu from the one we have just presented; their analysis makes use of the restriction operator to provide an alternative lexical entry for verbs which, like *likh* 'write' in (63), combine with light verbs like *de* 'let' to form a complex predicate. The restriction operator is used in a lexical rule that provides a new lexical entry for the main verb when it is used as a part of a complex predicate: the SUBJ of the original lexical entry of a verb like *likh* appears as a thematically restricted OBJ of a new lexical entry. This new lexical item must be used with light verbs that introduce a new subject, as *de* 'let' does.

Under Kaplan and Wedekind's proposals, complex predicate formation in Urdu occurs in the lexicon, not in the syntax. Butt et al. (2003) build on the proposals of Kaplan and Wedekind (1993), but show that the restriction operator can be used in f-descriptions in phrase structure rules, enabling complex predicate formation to be treated syntactically, in line with the argument structure analyses presented above. The use of the restriction operator is further discussed by Butt and King (2006b), who show that it can apply both in the syntax and within the morphological component of grammar, to model both syntactic and lexical complex predicate formation.

9.2. Complex Predicates Crosslinguistically

The crosslinguistic analysis of complex predicates has been a focus of LFG research since its earliest days. One of the earliest treatments of complex predicates in an LFG setting was proposed by Ishikawa (1985), who discusses Japanese morphological causatives, passives, potentials, and desideratives, and proposes to treat them as involving a type of raising that can involve the OBJ as well as the SUBJ of the complement verb. Ackerman and Webelhuth (1996, 1998) present a theory of complex predicates in which a single lexical item can be expressed by more than one morphological word. Matsumoto (1996) also explores the notion of word at different levels of linguistic representation, providing an illustrative examination of complex predicates in Japanese; Matsumoto (1998, 2000) examines Japanese causatives and proposes a parameter of semantic variation in the typology of causatives. Ackerman and Moore (2001) discuss argument linking in causatives and other structures in Finnic. Çetinoğlu et al. (2009) discuss the monoclausal status of causatives in Turkish, presenting an LFG-based analysis involving complex predication and argument structure merger. Spencer (2013, pages 286–294) discusses causative constructions in the context of his own model of argument structure.

Frank (1996) addresses the issue of complex predicate formation in French and Italian, noting that the assumption that complex predicates are formed in a similar manner in the two languages does not allow for a revealing analysis of the differences between them. She proposes a new sort of lexical rule that combines two verbs to produce a new lexical specification for complex predicates. On this view, complex predicate formation is lexically specified, though involving possibly discontinuous expressions consisting of more than one word. By contrast, Falk (2001b, pages 114–119) provides a rather more traditional, and influential, analysis of Romance causatives which captures commonalities in their structure.

Other phenomena involving complex predication which have received LFG analyses include: serial verbs (Bodomo 1996, 1997; Andrews and Manning 1999[18]), noun incorporation (Ball 2004; Asudeh and Ball 2005; Asudeh 2007; Duncan 2007; Nordlinger and Sadler 2008; Baker et al. 2010), directional complex predication in Choctaw (Broadwell 2000a), and a category of complex verbs involving an 'associated path' in some Australian languages (Simpson 2001). Seiss (2009) proposes criteria distinguishing light verb constructions, serial verb

[18]The approach of Andrews and Manning (1999) is LFG-based but architecturally quite different, involving structures resembling those used in Head-Driven Phrase Structure Grammar much more closely.

constructions, and auxiliary constructions, and Seiss and Nordlinger (2010) discuss complex predicates in Murrinh-Patha and the interactions of complex predicate formation, applicativization and reflexivization. Dras et al. (2012) provide an analysis of complex predicates in Arrernte which relies on glue semantics (Chapter 8). In a slightly different vein, Arka et al. (2009) provide a detailed analysis of the applicative construction in Indonesian that makes use of the restriction operator, and integrates this with an argument structure analysis involving predicate fusion in the morphology.

The identification of complex predicates, and the distinction between light verbs and auxiliaries, has also been a topic of investigation. Butt and Ramchand (2005) discuss the distinction between light verbs and auxiliaries in detail, concentrating on those that contribute aspectual semantics. Butt (2010) provides a comprehensive discussion of the identification of light verbs and complex predicates crosslinguistically. Butt and Lahiri (2013) discuss the diachrony of light verbs and complex predicates, with particular reference to Urdu and Bengali. They draw a clear distinction in diachronic terms between light verbs and auxiliaries, showing that light verbs are diachronically relatively stable in comparison to auxiliaries, and are more closely tied to their corresponding full verb.

10. GRAMMATICAL FUNCTIONS

In this section, we examine the issue of mapping from the standpoint of grammatical functions. This provides us with the opportunity to explore grammatical features and cross-classification from a slightly different perspective. We also consider the important issue of gradient distinctions and optionality.

10.1. SUBJ

The grammatical function SUBJ is classified as [−O,−R], making it nonobjective and semantically unrestricted. It is interesting to consider intransitive verbs and some of the ways in which their subjects may differ, specifically in relation to the *unergative/unaccusative distinction* (Section 4.4): the subject of an unergative intransitive verb is agent-like, while the subject of an unaccusative intransitive verb is patient-like.

Falk (2001b, page 111) observes that if a separate level of a-structure is assumed, it is possible to provide a straightforward account of the unergative/unaccusative distinction without the need for additional assumptions. Falk illustrates the difference between unergative and unaccusative verbs in English using the resultative construction.[19] As discussed in Section 4.4, when the verb in a

[19] On resultative constructions in Norwegian, see Lødrup (2000). Markantonatou and Sadler (1995) provide an analysis of English resultatives which departs in significant respects from standard assumptions of LFG and lexical mapping theory. Bresnan et al. (2016, Chapter 14) provide a brief discussion of resultatives, unergative intransitive verbs, and “fake” reflexives.

resultative construction is transitive, the resultative predicate applies to the more patient-like argument and not the more agent-like argument. This is true in both the active and the passive voice, whether the more patient-like argument is the OBJ or the SUBJ.

(76) a. *They wiped the table clean.*
b. *The table was wiped clean.*
c. **They wiped the table tired.*

Given this orientation to the patient-like argument, it is unsurprising to find that the subject of an unaccusative verb, which is patient-like, can control a resultative (77a), but the subject of an unergative verb, which is agent-like, cannot (77b).

(77) a. *My son grew tall.*
b. **John screamed hoarse.*

Kibort (2007) proposes the disjunctive classification [−O] or [−R] for $\arg_1$ in her version of mapping theory in order to account for the unergative/unaccusative distinction (Section 5). An unaccusative verb requires a [−R] argument, and shares this classification with the OBJ of a transitive verb like *wipe*, whereas an unergative verb requires a [−O] argument, and shares this classification with the SUBJ of a transitive verb like *wipe*. In this way, the grammaticality facts exemplified in (76) and (77) are captured. Bresnan et al. (2016, Chapter 14) provide further discussion of argument linking and unaccusativity.

10.2. OBJ

Börjars and Vincent (2008) discuss the grammatical function OBJ in detail, and its relation to the more general concept of "object" and the thematic role THEME. They identify many problems in the definition and distinction of OBJ as a distinct grammatical category, and argue that current versions of mapping theory which make use of binary feature decompositions of grammatical functions are inadequate when it comes to the specific properties of OBJ.

10.3. OBJ$_\theta$ and OBL$_\theta$

A number of authors have addressed the mapping of restricted [+R] arguments and the crosslinguistically common alternation between oblique arguments and restricted objects, for instance in the dative alternation and the applicative construction.

To illustrate first with an English example, the dative alternation involves three argument positions and three thematic roles (AGENT, THEME, BENEFACTIVE/RECIPIENT). The BENEFACTIVE/RECIPIENT can be expressed either as a PP oblique argument (78a) or as an object NP (78b).

(78) a. *John gave flowers to Mary.*

b. *John gave Mary flowers.*

Within the LFG framework, the dative alternation is discussed by Allen (2001) and Kibort (2008); Her (1999) examines the dative alternation in Chinese in the context of a new set of mapping proposals. Under the approach that we have adopted, following Kibort (2008), the dative alternation involves a pre-syntactic realignment of two of the participants in the event. In the construction illustrated in (78a), including the PP oblique argument which we identify as OBL$_{\text{GOAL}}$, the argument position associated with the BENEFACTIVE/RECIPIENT argument is arg$_4$; this is based on the set of semantic entailments invoked by the predicate in relation to this participant in the event. According to Kibort's theory, arg$_4$ is intrinsically associated with [−o]. Kibort proposes that the dative alternation involves the "remapping" of the BENEFACTIVE/RECIPIENT to primary object argument position (arg$_2$) plus the "downgrading" of the THEME to secondary object argument position (arg$_3$), as shown below. In the following examples, *b* represents the participant with the most proto-beneficiary/recipient properties.

(79) Ditransitive verb with oblique argument benefactive: *John gave flowers to Mary.*

$$
\begin{array}{llcccccl}
 & & & \text{x} & \text{y} & \text{b} & & \\
 & & & | & | & | & & \\
 & \textit{give}_1 & \langle & \text{arg}_1 & \text{arg}_2 & \text{arg}_4 & \rangle & \\
 & & & [-\text{o}] & [-\text{r}] & [-\text{o}] & & \\
\hline
\text{M.P.} & & & \text{SUBJ} & \text{OBJ} & \text{OBL}_{\text{GOAL}} & &
\end{array}
$$

(80) Ditransitive verb with shifted dative benefactive: *John gave Mary flowers.*

$$
\begin{array}{llcccccl}
 & & & \text{x} & \text{b} & \text{y} & & \\
 & & & | & | & | & & \\
 & \textit{give}_2 & \langle & \text{arg}_1 & \text{arg}_2 & \text{arg}_3 & \rangle & \\
 & & & [-\text{o}] & [-\text{r}] & \mathbf{[+o]} & & \\
\hline
\text{M.P.} & & & \text{SUBJ} & \text{OBJ} & \text{OBJ}_{\text{THEME}} & &
\end{array}
$$

The alternation between obliques and restricted objects is also discussed by Ackerman and Moore (2011), while the dative alternation has been the subject of much work by Joan Bresnan and colleagues; see, for example, Bresnan et al. (2007a), Bresnan (2007), Bresnan and Nikitina (2010), Bresnan and Hay (2008), Bresnan and Ford (2010), Kendall et al. (2011), de Marneffe et al. (2012), and Ford and Bresnan (2013).

Applicative constructions, which involve the addition of an argument to a predicate's subcategorization frame, are discussed by Bresnan and Moshi (1990), Alsina and Mchombo (1990), Kibort (2007, 2008), Arka et al. (2009), and Ackerman and Moore (2011, 2013). The benefactive applicative construction in Chicheŵa is illustrated in (81b). In each of the sentences in (81), the argument that immediately follows the verb is the primary (nonrestricted) object:

(81) a. Non-applied transitive construction:

nkhandwe zi-ku-mény-á njō̄vu
10.foxes 10SUBJ-PRS-hit-FV 9.elephant
'The foxes are hitting the elephant.'

b. Benefactive applicative construction:

nkhandwe zi-ku-mény-ér-a aná njō̄vu
10.foxes 10SUBJ-PRS-hit-APPL-FV 2.children 9.elephant
'The foxes are hitting the elephant for the children.'

Kibort (2008) analyses the benefactive applicative construction as involving the addition of an argument pre-specified as [+O] to the valency frame of the predicate in question, resulting in an increase in valence. Note that while (83) and the analysis provided for the construction that includes the English shifted dative benefactive in (80) are the same, it is only the applicative construction that is morphologically marked.

(82) Non-applied transitive construction:

$$
\begin{array}{llcccl}
 & & \text{x} & \text{y} & & \\
 & & | & | & & \\
 & \textit{hit} & \langle\ \text{arg}_1 & \text{arg}_2\ \rangle & & \\
 & & [-\text{O}] & [-\text{R}] & & \\
\hline
\text{M.P.} & & \text{SUBJ} & \text{OBJ} & &
\end{array}
$$

(83) Benefactive applicative construction:

$$
\begin{array}{llccccl}
 & & \text{x} & \text{b} & \text{y} & \\
 & & | & | & | & \\
 & \text{(applicative) }\textit{hit} & \langle\ \text{arg}_1 & \text{arg}_2 & \text{arg}_3\ \rangle & \\
 & & [-\text{O}] & [-\text{R}] & \mathbf{[+O]} & \\
\hline
\text{M.P.} & & \text{SUBJ} & \text{OBJ} & \text{OBJ}_{\text{THEME}} &
\end{array}
$$

In the context of the applicative construction, a number of authors have discussed the phenomenon of "object asymmetries" and the distinction between symmetrical and asymmetrical object languages. Bresnan and Moshi (1990) show in detail that there is a distinction between "asymmetrical object type" languages, in which only one of a verb's complements can exhibit primary object properties like passivizability, and "symmetrical object type" languages, in which more than one of the verb's complements is potentially able to display such properties. In some symmetrical languages, certain subclasses of objects can show asymmetric patterns due to factors such as person and animacy. Bresnan and Moshi (1990), building on an analysis proposed by Alsina and Mchombo (1993) for Chicheŵa, argue that a single parameter can account for the difference between symmetrical and asymmetrical languages: the "Asymmetrical Object Parameter" (AOP), which holds in asymmetrical languages such as Chicheŵa. The AOP is a constraint on intrinsic classifications, such that only one argument position may be intrinsically classified as unrestricted. This means, for example, that at most one argument of a predicate is available to become the subject of a passive construction. The AOP is also discussed by Falk (2001b, pages 111–114). Kibort (2008) claims that object asymmetries are easily handled in her model of argument structure, since according to the universal valency template in (37), only one argument position is classified as [−r].

10.4. COMP and XCOMP

There has been comparatively little work on mapping of the grammatical functions comp and xcomp. Zaenen and Engdahl (1994) were among the first to propose a detailed theory of mapping to comp and xcomp, assuming that these arguments bear the thematic role proposition and are intrinsically associated with the [−o] feature.[20] Butt (1995) and Alsina (1996) also discuss the application of linking theory to xcomp, comp, and raising verbs.

It is worth noting that clausal arguments need not map onto comp and xcomp. As discussed in Chapter 2, Section 1.7, some clausal arguments have been analyzed as obj, obj$_\theta$, or obl$_\theta$. Arka and Simpson (2008) argue on the basis of control phenomena in Balinese that clausal arguments can have the intrinsic classification [−r], and that consequently complex clausal arguments can map to subj, obj, or obl$_\theta$. Rákosi and Laczkó (2005) make the same point for clausal arguments in Hungarian.

10.5. Gradient Distinctions and Optionality

Early models of argument structure within LFG were based on the assumption that the distinctions between argument and adjunct, on the one hand, and between core (subj, obj, obj$_\theta$) and oblique (obl$_\theta$) arguments, on the other, are absolute distinctions which can be made unambiguously in any particular context. However, a growing body of work within LFG has sought to address phenomena which point instead toward a gradient distinction between arguments and adjuncts, and between core and oblique arguments.

10.5.1. The Core-Oblique Distinction

Arka (2005) discusses the nature of what he labels the “core-oblique” distinction in Austronesian languages spoken in Indonesia, and particularly the obj/obl$_\theta$ distinction. Arka argues in detail that there is no absolute distinction between obj and obl$_\theta$ in some languages. He proposes a “core index”, based on a set of language-specific syntactic properties characteristic of core arguments. The index ranges from 1.00 (“highly core”) to 0.00 (“highly oblique”). Arka shows that in Indonesian and Balinese the core index of core arguments can vary, but it is always over 0.60, while the core index of typical obliques is between 0.00

[20] Zaenen and Engdahl (1994) also discuss argument mapping and nonthematic or semantically empty arguments, which they claim are present at argument structure with the intrinsic feature [−r]; see Bresnan et al. (2016, page 332) for additional discussion.

and 0.10. However, certain arguments of verbs in Indonesian have a core index around 0.50. This is the case, for example, with the stimulus NP argument of Indonesian *suka* 'like', which has a core index of 0.54. The puzzle of how to classify this stimulus argument is also discussed by Musgrave (2001, 2008), who argues that this argument cannot be classified as either SUBJ or OBJ. The best analysis within the inventory of LFG's grammatical functions is, Musgrave argues, OBJ_θ. Arka (2005) rejects this proposal on the basis that the stimulus argument does not show sufficient core properties. Both Arka (2005) and Musgrave (2008) consider the possibility of adding to LFG's inventory of grammatical functions a 'semi-OBJ' function, but they both dismiss this as a viable option given that such a class would be only negatively defined and not necessarily coherent. Arka (2005) argues that the best solution may be to reanalyze the distinctions between grammatical functions so that only subject and complement are differentiated.

10.5.2. Optional Dependents: Derived Arguments, Thematic Adjuncts

Another distinction which appears to be problematic when conceived of as binary and discrete is the argument/adjunct distinction. Key to this issue are those constituents whose properties indicate that they do not belong unambiguously to either category. For instance, Rákosi (2006a,b) discusses the status of so-called 'circumstantial' dependents, such as comitatives, instrumentals and benefactives, which are realized as PPs in English. Within LFG, such dependents are usually treated as arguments. However, they are different from prototypical arguments in a number of ways, most obviously in the fact that they are optional. In the sentences in (84), the subject and object arguments cannot be omitted, whereas in each case the PP dependent is optional.

(84) a. *David selected Chris (for the first team).*

b. *The masked man assassinated the president (with a knife).*

The standard LFG approach to such dependents, following Bresnan (1982d), is to treat them as arguments, and to treat their optionality by means of a lexical rule which creates new verb forms by the addition of an argument to the lexical representation. The lexical rule *Instrumentalization*, for example, derives the verb in example (85b) from the one in (85a) by adding an instrumental argument:

(85) a. *assassinate* ⟨ AGENT, PATIENT ⟩

b. *assassinate* ⟨ AGENT, PATIENT, INSTRUMENT ⟩

The version of (84b) which lacks the PP contains the verb in (85a), while the version of (84b) which includes the PP contains the related but distinct verb in (85b). The optionality of such dependents is therefore not due to any essential difference in status between them and the SUBJ or OBJ arguments of the same predicates: when the PP is present it is as much an argument, and no less obligatory, than the subject and object arguments. The PP's optionality is only apparent, due to the existence of two distinct lexical entries for the governing verb, one of which selects for an obligatory INSTRUMENT argument, the other of which does not.

However, Rákosi (2006a,b) shows that a more fine-grained approach to optional dependents is required in order to capture the full range of variation in the status of such dependents. In particular, some such optional dependents are, in semantic terms, entailed by the meaning of the predicate, and so must form part of the lexical conceptual structure of the verb. Rákosi (2006b) contrasts English *assassinate* with a verb like *drill*.[21] Superficially, the instrumental dependent of *drill* appears to be just like the instrumental dependent of *assassinate*, since it is optional:

(86) a. *David drilled the hole (with the hand drill).*

b. *The masked man assassinated the president (with the knife).*

However, there is a difference between the two: *assassinate* does not necessarily entail the existence of an instrument, whereas *drill* does. Rákosi (2006b) claims that "one can in principle assassinate the president simply by jumping on him/her", while it is not possible to drill something without an instrument. This difference is reflected grammatically since, as noted by Reinhart (2002), there exists a variant of verbs like *drill* in which the instrument functions as the subject, whereas there exists no such variant for verbs like *assassinate*:

(87) a. *The hand drill drilled the hole.*

b. **The knife assassinated the president.*

On the basis of such observations, Rákosi argues that the optional dependents of verbs like *assassinate* are intermediate, in descriptive terms, between arguments proper and adjuncts proper. In formal terms, however, Rákosi seeks to maintain the absolute distinction between arguments and adjuncts which is fundamental to the treatment of grammatical functions in LFG. In order to resolve this paradox, Rákosi argues for a class of *thematic adjuncts* (ADJ_θ), which are adjuncts in syntactic terms but which bear a thematic relation to the predicate, unlike "pure" adjuncts.[22]

A particular subset of the constituents which Rákosi (2006a,b) treats as thematic adjuncts, namely optional *to*-PPs with verbs like *seem*, receives a different analysis from Asudeh and Toivonen (2007, 2012). Asudeh and Toivonen refer to these PP experiencers as instantiating a semantic role of PGOAL (goal of perception). They argue that such dependents should be treated as "pure" adjuncts, but ones which bear a semantic relation to the predicate without bearing a relation in syntactic or argument structure terms.

[21] In fact, Rákosi (2006b) bases his discussion on the verb *peel*, following Reinhart (2002) in classifying this verb as entailing the existence of an instrument. However, it is possible to peel an orange or tangerine without the aid of a peeling instrument; in fact, *peel* patterns with verbs like *eat* in allowing but not requiring the presence of an instrument.

[22] For a similar treatment motivated primarily by implementational concerns, see Zaenen and Crouch (2009).

As mentioned above, the standard LFG analysis of the type of optional dependents that Rákosi (2006a,b) analyses as thematic adjuncts is, following Bresnan (1982d), to treat them as arguments. This approach is explored further by Needham and Toivonen (2011), who discuss a variety of optional dependents whose status is, they argue, intermediate between true argument and true adjunct. They present a number of argumenthood tests, showing that several types of optional dependents display inconsistent properties. These include the constituents in parentheses in the following examples: the demoted subject in a passive (88a), possessive phrases with event nominals (88b), benefactives (88c), "displaced" themes (88d), instruments (88e), experiencers (88f), and directionals (88g).

(88) a. *The letter was written (by David).*

b. *David's writing of the letter / The writing of the letter*

c. *David cooked a meal (for Chris).*

d. *David loaded the wagon (with hay).*

e. *David cut up the apple (with a knife).*

f. *It looks (to me) like it's going to rain.*

g. *David arrived (from London) yesterday.*

In clarifying their concept of argumenthood, Needham and Toivonen (2011) address the problem of semantic entailment, i.e. whether the existence of a particular argument role is entailed by a predicate. They point out (as also observed in Chapter 2) that it is not, in fact, helpful to think of arguments as "entailed" or "semantically necessary", because the existence of a time and place at which an event occurs is necessarily entailed by every verb, yet such concepts are almost universally expressed using adjunct phrases. What matters instead is *verb specificity*: arguments are "semantically distinctive", that is, they are associated with particular classes of verbs, and thus serve to distinguish those classes from other classes. Time and place are therefore not likely to be expressed as arguments, because they are relevant to the majority of verbs and so do not generally distinguish between verb classes.

With this definition of argument in place, Needham and Toivonen (2011) pursue a mapping-theoretic analysis of optional dependents which is similar in spirit to the proposals of Bresnan (1982d) in treating them as *derived arguments*. In the case of instrumentals, for example, they provide a lexical rule which is roughly equivalent to Bresnan's *Instrumentalization*, exemplified in (85). Reformulated in terms of the approach that we have been using, following Kibort's work, the rule would look like this:

(89) Optionally add the following argument to verbs whose first argument is an agent:

$$\begin{array}{ll} & \text{y} \\ & | \\ & \text{arg}_4 \\ & [-\text{o}] \\ \text{M.P.} & \overline{\text{OBL}_{\text{INSTR}}} \end{array}$$

Similar optional lexical rules are proposed for the other optional dependents exemplified in (88).

The argument-adjunct distinction continues to be a focus of research within LFG; see, for example, Toivonen (2013), Rákosi (2013), and Przepiórkowski (2017). To date, such research has overwhelmingly focused on data from English. As Needham and Toivonen (2011) observe, a fuller understanding of this issue is likely to be gained in light of data from a wider range of languages.

Building on the derived argument approach of Needham and Toivonen (2011), Asudeh and Giorgolo (2012) propose an integrated syntactic and semantic analysis of the argument-adjunct distinction.[23] They argue that the standard LFG approach, involving distinct lexical entries for verbs that have optional dependents, fails to capture the intuition that fundamentally the same verb is involved in both of the following sentences, for example:

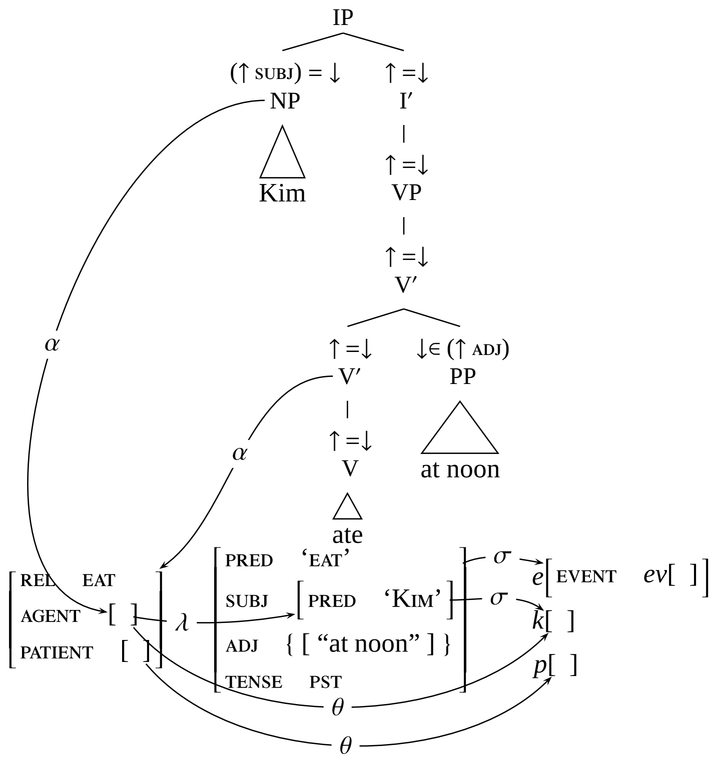
(90) a. *David ate.*

b. *David ate cheese.*

Asudeh and Giorgolo (2012) propose to capture such patterns by using optional f-descriptions within a single lexical entry. In presenting their analysis, Asudeh and Giorgolo contrast their model specifically with that of Butt et al. (1997), presented in Section 2, according to which argument structure is interpolated between c-structure and f-structure. Asudeh and Giorgolo argue that such an approach could deal with optional dependents only if a further correspondence function were assumed between a-structure and s-structure. That is because the PATIENT argument of a verb like *eat*, for example, must be present at argument structure and semantic structure even if it is not realized in the c-structure and does not appear in the f-structure. Therefore, alongside the decomposition of the ϕ function into a function α (from c-structure to a-structure) and a function λ (from a-structure to f-structure), it would also be necessary to assume a function, which Asudeh and Giorgolo (2012) label θ, from a-structure to s-structure. On this view, θ is the composition of λ with σ, as shown in example (91).

[23] For an alternative implementation of the same proposal using monads, building on Giorgolo and Asudeh (2011a), see Giorgolo and Asudeh (2012b).

(91) Necessary adjustment to Butt et al.'s proposal, considered and rejected by Asudeh and Giorgolo (2012):



As discussed in Section 5, Asudeh and Giorgolo (2012) propose an alternative, architecturally simpler model in which no distinct a-structure and no additional correspondence functions are required. Under this approach, grammatical functions at f-structure are directly associated with s-structure attributes in the lexical entries of predicates. Lexical entries also include an obligatory meaning constructor that represents the essential meaning of a predicate; additional optional meaning constructors can introduce or existentially quantify optional arguments. For example, Asudeh and Giorgolo (2012) provide the following lexical entry for English *ate*, modified in accordance with the version of mapping theory proposed by Findlay (2014, 2016) (see also Asudeh et al. 2014):

(92) *ate* V $(\uparrow \textsc{pred}) = \text{`}\textsc{eat}\text{'}$
$(\uparrow \textsc{tense}) = \textsc{pst}$

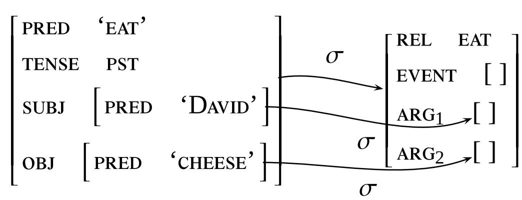
$(\uparrow \textsc{subj})_\sigma = (\uparrow_\sigma \textsc{arg}_1)$
$\{(\uparrow \textsc{obj})_\sigma = (\uparrow_\sigma \textsc{arg}_2) \mid (\uparrow_\sigma \textsc{arg}_2)_{\sigma-1} = \emptyset\}$

$\lambda x.\lambda y.\lambda e.\mathit{eat}(e) \wedge \mathit{agent}(e) = x \wedge \mathit{patient}(e) = y :$
$(\uparrow_\sigma \textsc{arg}_1) \multimap [(\uparrow_\sigma \textsc{arg}_2) \multimap [(\uparrow_\sigma \textsc{event}) \multimap \uparrow_\sigma]]$

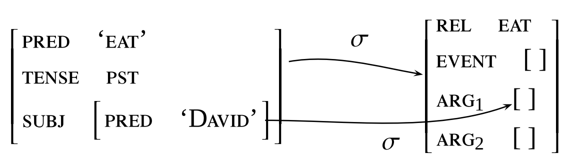
$\begin{pmatrix} \lambda P.\lambda e.\exists x.P(e,x) : \\ [(\uparrow_\sigma \textsc{arg}_2) \multimap (\uparrow_\sigma \textsc{event}) \multimap \uparrow_\sigma] \multimap [(\uparrow_\sigma \textsc{event}) \multimap \uparrow_\sigma] \end{pmatrix}$

Line 3 of the lexical entry in (92) associates the s-structure of the SUBJ with the s-structure attribute $\textsc{arg}_1$. Line 4 ensures that $\textsc{arg}_2$ is mapped appropriately *unless* it is unrealized. The rest of the lexical entry comprises meaning constructors. The first meaning constructor introduces the meaning *eat* of the verb and its agent and patient, and is obligatory. The second meaning constructor (enclosed in parentheses) is optional, and existentially quantifies over the patient argument, allowing the verb to appear with only the agent expressed. These f-descriptions license the two analyses shown below, which capture the two different uses of the optionally transitive verb *eat*.

(93) F-structure and s-structure for *David ate cheese*, Asudeh and Giorgolo (2012):



(94) F-structure and s-structure for *David ate*, Asudeh and Giorgolo (2012):



Under these proposals, the verb *eat* in English has two arguments at s-structure, regardless of whether the object argument is realized at c-structure and f-structure; it is realized syntactically in (93), but not in (94). Importantly, we are dealing with only one lexical entry — only one verb *eat* — whether or not the optional object is present.

Asudeh and Giorgolo (2012) also provide an analysis for instrumental *with*-phrases, based on the derived argument approach of Needham and Toivonen (2011). They propose that argument addition is best captured by associating the relevant lexical information with the entry of the instrumental preposition *with*, as in (95), rather than the verb.

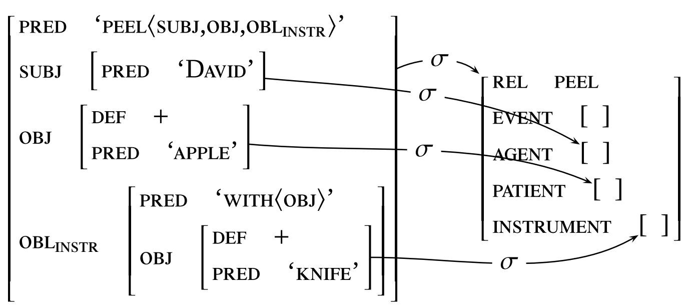
(95) *with* P $(\uparrow \textsc{pred}) = \text{`}\textsc{with}\text{'}$

$$(\uparrow \textsc{obj})_\sigma = ((\textsc{obl}\uparrow)_\sigma\ \textsc{instrument})$$

$$\begin{aligned}&\lambda y.\lambda P.\lambda x.\lambda e.[P(x)(e) \wedge \mathit{animate}(x) \wedge \mathit{instrument}(e) = y] :\\ &\quad (\uparrow \textsc{obj})_\sigma \multimap\\ &\quad [((\textsc{obl}\uparrow)\ \textsc{subj})_\sigma \multimap ((\textsc{obl}\uparrow)_\sigma\ \textsc{event}) \multimap (\textsc{obl}\uparrow)_\sigma] \multimap\\ &\quad ((\textsc{obl}\uparrow)\ \textsc{subj})_\sigma \multimap ((\textsc{obl}\uparrow)_\sigma\ \textsc{event}) \multimap (\textsc{obl}\uparrow)_\sigma\end{aligned}$$

This lexical entry not only includes the information that the derived argument is an instrument, but also requires the SUBJ to be animate, capturing the generalization that instrumental *with*-phrases are only possible with "agent verbs" (Reinhart 2002). Example (96) shows the f-structure and s-structure for the sentence *David peeled the apple with the knife* (example 86), based on Asudeh and Giorgolo's (2012) proposal:

(96)



In addition to optional transitives and instrumental *with*-phrases, Asudeh and Giorgolo (2012) provide an analysis of passive constructions with and without a *by*-phrase, and consider the wider implications of this approach for the argument-adjunct distinction and the LFG architecture as a whole.

11. FURTHER READING AND RELATED ISSUES

The discussion in this chapter cannot do justice to the large volume of literature on argument structure and its place in the LFG architecture. For more on the nature of and motivation for argument structure, see Simpson (1991, Chapter 1), who presents an interesting discussion of thematic roles, syntactic functions, and the regularities that hold between syntax, semantics, and argument structure. Falk

(2001b) provides a useful overview, including a very interesting discussion of linking in ditransitive verbs. Theories of argument linking and argument structure and their development within LFG are discussed in detail by Butt (2006, Chapter 5). Bresnan et al. (2016, Chapter 14) also provide an overview discussion of argument structure and mapping theory, discussing a range of alternative approaches and providing pointers to related literature.

The concept of argument structure, and the specific proposals of mapping theory, have been subject to criticism, for example by Davis and Koenig (2000) and Levin and Rappaport Hovav (2005); their arguments are addressed and countered by, among others, Ackerman and Moore (2013) and Spencer (2013, Chapter 7).

As mentioned earlier, a number of alternative proposals have been made regarding the theory of argument mapping and argument classification. Alsina (1996) argues for a very different feature decomposition of grammatical functions, making use of the features ±SUBJ, indicating whether or not the argument is "subject-like," and ±OBL, indicating whether the argument is a direct (−OBL) or an oblique argument. Alsina also eliminates the Function-Argument Biuniqueness condition, arguing that its elimination allows the correct treatment of, among other constructions, reflexive clitics in some Romance languages.

Rákosi (2006a,b) proposes a different feature decomposition of grammatical functions, based on Reinhart's (2002) Theta System decomposition of thematic roles. Rákosi makes use of Reinhart's binary features ±*c(ause)* and ±*m(entally involved)*. In this system, absence of a feature differs from a minus value for that feature. For example, the [+*c*,+*m*] role corresponds to the thematic role of AGENT, the [+*c*,−*m*] role corresponds to the thematic role of INSTRUMENT, and the [+*c*] role corresponds to a thematic role CAUSE.

Linking in nominal predicates has been a subject of interest since relatively early in the theory's development, and continues to be a focus of research. Iida (1987) and Saiki (1987) discuss deverbal nominals in Japanese, the realization of grammatical functions in nominals, and the role of argument structure; Markantonatou (1992, 1995) presents an analysis of linking in deverbal nominals in Modern Greek. Laczkó (1995, 2000) presents a detailed analysis of the syntax of Hungarian noun phrases, including a theory of linking of nominal arguments. An alternative theory of linking for nominal arguments is provided by Kelling (2003).

Another proposal for linking nominal arguments is made by Chisarik and Payne (2003). They argue for a third binary feature [±D] "discourse-related", alongside [±R] and [±O]. This feature serves to distinguish two [−O], [−R] functions: SUBJ and "ADNOM". Both of these functions can be governed by nominals, but ADNOM cannot be governed by verbs.

A topic of debate in the literature concerns whether nominals can select for unrestricted [−R] functions, or only restricted [+R] functions. Rappaport (1983) and Kelling (2003) argue that nominals can govern only restricted functions. Markantonatou (1995) assumes that nominals can select for both restricted and unrestricted functions. According to Laczkó (2000), deverbal nominals can select for both restricted and unrestricted functions, with POSS being an unrestricted function. Laczkó's research also includes work on event nominalizations (Laczkó 2003, 2013). The selectional possibilities for adjectives are discussed by Vincent and Börjars (2010a), while subcategorization by both nouns and adjectives is discussed by Lowe (2013, 2017b). Spencer (2013, Chapter 7) develops a theory of argument structure representation which is primarily designed to model attributive modification; he also briefly discusses adverbial and prepositional argument structure.

A variety of other phenomena with interesting argument structure properties have been discussed within the context of mapping theory. That some two-argument verbs can select for a SUBJ and an OBJ_θ, rather than the usual SUBJ and OBJ, is discussed by Çetinoğlu and Butt (2008), Dahlstrom (2009, 2013) and Dalrymple and Nikolaeva (2011). Valency alternations in Balinese, which exhibits a partially symmetrical voice system, are discussed by Arka (2003) and Arka and Simpson (2008). Arnold (1994) provides an analysis of inverse voice in Mapudungan.

In his work on argument alternations, Findlay (2014, 2016) develops an account within the framework of Asudeh and Giorgolo (2012) which utilizes the argument structure model proposed by Kibort (2001, 2004, 2006, 2007, 2008), drawing together these two approaches to argument mapping and subcategorization.

There is a small body of work within LFG's mapping theory that has been conducted within an Optimality-Theoretic framework (Prince and Smolensky 2004): Lødrup (1999b) provides an analysis of the Norwegian presentational focus construction; Asudeh (2001) proposes an account of argument linking in Marathi, noting some consequences for Dowty's (1991) theory of proto-roles; Morimoto (1999) presents an analysis of locative inversion and argument reversal, and Morimoto (2000) continues this work. Optimality-Theoretic approaches to LFG more generally are briefly discussed in Chapter 18, Section 1.3.

10

INFORMATION STRUCTURE

We now consider how information is organized, or structured, within an utterance. As with semantic information, early work in LFG represented certain aspects of information packaging by means of f-structure attributes. Subsequent work assumes a separate level of *information structure*, related to other structures via correspondence functions. In this chapter, we begin by discussing how the information conveyed by an utterance is structured or packaged to facilitate communication, and we explore the nature of the units that are relevant to the structuring of information. We then review some early LFG approaches to the representation of information structural features, followed by an overview of the model of information structure that we adopt in the rest of this book.

1. STRUCTURING INFORMATION

The main function of language is the exchange of information between participants. *Information structure* is the level of sentence organization that represents how sentences are structured in a particular context in order to facilitate information exchange.[1] All languages make it possible to facilitate information exchange by, for example, highlighting certain pieces of information as particularly relevant or important, or by distinguishing pieces of information that are entirely new in the discourse from pieces of information that are "old", corresponding to information already present in the relevant context or discourse. As a result, the same proposition can be expressed by sentences with different structures. For instance, the Russian sentences in (1) (Comrie 1987, page 95) encode the same proposition and are truth-conditionally equivalent, regardless of the difference in word order. In both cases, the individual called Maxim defends the individual called Victor.

(1) a. *Viktor-a zaščiščaet Maksim.*
Victor-ACC defends Maxim.NOM
'Maxim defends Victor.'

b. *Maksim zaščiščaet Viktor-a.*
Maxim.NOM defends Victor-ACC
'Maxim defends Victor.'

However, these sentences are not interchangeable: their acceptability is dependent on the precise discourse context. In the context provided in (2a), (1a) is the most natural way to answer a question about the subject of the sentence (the defender); in the context provided in (2b), (1b) is the most natural way to answer a question about the object of the sentence.

(2) a. Q: *Kto zaščiščaet Viktor-a?*
who.NOM defends Victor-ACC
'Who defends Victor?'

A: *Viktor-a zaščiščaet Maksim.*
Victor-ACC defends Maxim.NOM
'Maxim defends Victor.'

b. Q: *Kogo zaščiščaet Maksim?*
who.ACC defends Maxim.NOM
'Who does Maxim defend?'

A: *Maksim zaščiščaet Viktor-a.*
Maxim.NOM defends Victor-ACC
'Maxim defends Victor.'

Russian has a high degree of word order flexibility, meaning that constituents can appear in different orders for the purpose of encoding information structure distinctions. Another possibility is for a language to use specific constructions

[1] There are different uses of the term "information structure" in the literature. O'Connor (2006) uses i(nformation)-structure as a term for relations between multiple levels, including prosody and semantics, and refers to the level at which information is organized within an utterance as d(iscourse)-structure. Here, we use the more standard term "information structure" (or i-structure) for this level, and the term "discourse structure" rather for the relations between successive utterances in a discourse, following King and Zaenen (2004). We will not have anything detailed to say on discourse structure in this book.

which can be used to "package" information. For instance, in English a cleft construction can be used as an answer to a constituent question when the clefted element is the "answer" constituent; in (3) A is a discourse felicitous response, and A′ is infelicitous in the context provided.[2] (A′ would, on the other hand, be an acceptable response to the question *Who hates beans?* while A would not be.)

(3) Q: *What does David hate?*
A: *It's beans that David/he hates.*
A′: *#It's David that hates beans.*

Of course, syntax is not the only means by which information structure can be encoded crosslinguistically. Morphology and prosody may also be used to package information, either on their own or in combination. An example of how morphology can encode information structure status in some languages is differential object marking; Dalrymple and Nikolaeva (2011) provide an LFG analysis which makes an explicit link between object marking and information structure in a number of languages. With respect to prosody, the location of the main stress in an English sentence (indicated by bold face in the following example) in part depends on information structure, as the infelicity of A′ in response to this particular question illustrates:

(4) Q: *Who bought flowers?*
A: ***Lily** bought flowers.*
A′: *#Lily **bought** flowers.*

We provide a detailed discussion of the relationship between prosody and information structure in Chapter 11, Section 6. In this chapter, we assume 'neutral' intonation and confine ourselves to the syntactic encoding of information structure.

Crosslinguistically, languages differ in the extent to which syntax encodes information structural distinctions. At one end of the spectrum are *nonconfigurational* languages. These are languages whose word order appears flexible if one considers only grammatical functions such as subject and object, but where word order is in fact often determined on the basis of information structure relations. For example, as discussed in Chapter 3, Section 4.2, Warlpiri is a nonconfigurational language: beyond requiring that the auxiliary verb occupy a particular syntactic position, no purely syntactic generalization can adequately account for word ordering in Warlpiri. A *configurational* language like English is fundamentally different in this respect: phrase structure positions in English tend to be associated with particular grammatical functions, and word order is thus highly restricted in this respect. For instance, the grammatical subject in an English sentence appears in the specifier of IP, regardless of its information structure status. The answer A in (5), with *David* in the specifier of IP, is an acceptable response to either Q or Q′:

[2] The symbol '#' indicates semantic or pragmatic unacceptability, in the same way as the asterisk '*' indicates syntactic ill-formedness.

(5) Q: *Who selected Chris?*
Q′: *Who did David select?*
A: *David selected Chris.*

Another possibility attested in many languages, particularly those with rich morphological agreement systems, is *discourse configurationality*. In a discourse-configurational language, phrase structure and word order are determined not by grammatical function but by information structure status. As in a configurational language (or more accurately a *grammatical function configurational* language), therefore, word order is highly restricted. The key difference between these two types of configurational language is whether word order is determined on the basis of information structure categories such as topic and focus (which we will define shortly) or grammatical functions such as subject and object. Snijders (2015) claims that word order in all languages is constrained either syntactically (in terms of grammatical functions) or by information structure relations; that is, all languages which have been classified as nonconfigurational, such as Warlpiri, are in fact discourse-configurational.

Hungarian is a discourse-configurational language. In Hungarian, the constituent which supplies the missing information elicited by a question (the *focus* of the answer sentence) occupies the immediately preverbal position, regardless of its grammatical function.

(6) a. Q: *János ki-t hívott fel?*
John.NOM who-ACC called VM
'Who did John call?'

A: *János [Mari-t]*$_{\text{FOCUS}}$ *hívta fel.*
John.NOM Mary-ACC called VM
'John called Mary.'

b. Q: *Mari-t ki hívta fel?*
Mary-ACC who.NOM called VM
'Who called Mary?'

A: *Mari-t [János]*$_{\text{FOCUS}}$ *hívta fel.*
Mary-ACC John.NOM called VM
'John called Mary.'

A language may be discourse configurational to a greater or lesser degree, making it difficult to establish a strict division between configurational languages and discourse-configurational languages. For example, Catalan (Vallduví 1992) is a language which is discourse configurational only with respect to certain types of topic; focus, by contrast, is not associated with a particular phrase structure position (Erteschik-Shir 2007, page 85).

Before we consider how the relationship between syntax and information structure has been analyzed within the LFG framework, it is necessary to negotiate the "terminological minefield" (Vallduví and Vilkuna 1998, page 80) that is a feature of research on pragmatics and information structure. In the next section, we define the key concepts that underlie the definitions of information structure units that have generally been adopted in LFG analyses.

2. THE CATEGORIES OF INFORMATION STRUCTURE

There are many different theories of the ways that information is structured in language, with studies of the relation between syntax and information structure stretching back at least to the 11th century Arabic grammarian Al-Jurjani (see Owens 1986, among others). Perhaps the most widely known information structure distinction, due to Weil (1844), is between "Topic" or "Theme" — what the sentence is about, the "point of departure" — and "Comment" or "Rheme", what is stated about the topic. Though the precise definitions of these terms may vary, this fundamental bifurcation in one way or another underlies much subsequent work on the categories of information structure, including important work within the Prague School tradition (for example Daneš 1974; Firbas 1964; Hajičová et al. 1998; Mathesius 1983; Sgall 1967) and beyond (for example, Bolinger 1965; Dahl 1969; Gundel 1974; Halliday 1967; Kuno 1972).[3] To give an example, the answer to the question translated as *Who did John call?* in the Hungarian dialogue in (6a), repeated here as (7), can be divided into Topic and Comment as shown:

(7) *János* *Mari-t* *hívta* *fel.*
$\underbrace{\text{John.NOM}}_{\text{TOPIC}}$ $\underbrace{\text{Mary-ACC called VM}}_{\text{COMMENT}}$
'John called Mary.'

Another key binary distinction made in the information structure literature is between "Background" or "Presupposition" and "Focus" (for example, Chomsky 1971; Jackendoff 1972; Krifka 1991; Lambrecht 1994; Prince 1981; Steedman 1991). This distinction relates to whether the information in question can be assumed to be shared by the interlocutors (Background) or not (Focus). Thus, as with the Topic/Comment distinction, the fundamental insight is that information is structured in such a way as to relate the utterance to the wider discourse context and to satisfy the communicative requirements of the discourse participants. The information expressed in the Hungarian example (7) can be divided on the basis of this distinction as well, resulting in a different division to the previous Topic/Comment one:

[3] A useful summary of information structure terminologies and their dependencies in 20th century research is provided by Kruijff-Korbayová and Steedman (2003); see also Erteschik-Shir (2007) for an overview.

(8) *János* *Mari-t* *hívta* *fel.*
$\underbrace{\text{John.NOM}}_{\text{BACKGROUND}}$ $\underbrace{\text{Mary-ACC}}_{\text{FOCUS}}$ $\underbrace{\text{called VM}}_{\text{BACKGROUND}}$
'John called Mary.'

The categories of topic and focus have been of particular importance in the analysis of information structure in the LFG literature. Based on much previous research, including Gundel (1974), Reinhart (1981), and Lambrecht (1994), we understand topic to be the entity or entities that the proposition is about. We understand focus to be the informationally unpredictable part of the proposition, that which is informative or contrary to expectation (Vallduví 1992; Vallduví and Engdahl 1996), or in Lambrechtian terms, the semantic component of a pragmatically structured proposition whereby the assertion differs from the presupposition (Lambrecht 1994). For more on the definitions of topic and focus in an LFG setting, see Dalrymple and Nikolaeva (2011).

One approach to information structure and its primitives which has been particularly influential within LFG is that of Vallduví (1992). Vallduví proposes a trinomial articulation, integrating key insights relating to the two bifurcations described and exemplified above, which he uses to analyze the syntax-information structure interface in Catalan. He distinguishes between ground and focus, parallel to the Background/Focus distinction in other works on information structure. He additionally proposes that ground information can be further divided into *link* and *tail*. In relating Vallduví's (1992) approach to more traditional information structure categories, Choi (1999, pages 75-76) states that "we can interpret link as topic ... or theme ..., which is, roughly speaking, what the sentence is 'about', and tail as 'other' given information or the rest of the ground information, which is less conspicuous in the sentence". Under such an analysis, the information structure of our Hungarian example would be classified like this:

(9) *János* *Mari-t* *hívta* *fel.*
$\underbrace{\text{John.NOM}}_{\text{BACKGROUND}}$ $\underbrace{\text{Mary-ACC}}_{\text{FOCUS}}$ $\underbrace{\text{called VM}}_{\text{TAIL}}$
'John called Mary.'

Working within the LFG framework, Choi (1999) proposes an analysis of the relationship between syntax and information structure in German and Korean which takes Vallduví's approach as its starting point.[4] Choi acknowledges the importance of the categories which Vallduví proposes, but also points out that even a trinomial system is not sufficiently fine-grained to capture the data whose analysis is her main concern. She therefore proposes a feature-based approach to information structure, in which a term like "topic" is a label for certain values of a pair of binary-valued features. The advantage of such a system is that it allows reference to linguistically significant natural classes of roles sharing a common

[4]In fact, Choi (1999) proposes an Optimality Theory (OT)-LFG analysis. For a brief overview of OT-LFG, see Chapter 18, Section 1.3.

Table 10.1: Information features and discourse functions according to Choi (1999, page 92)

	+PROM	−PROM
+NEW	contrastive focus	completive focus
−NEW	topic	tail

feature. Choi proposes two such features in her system to encode information structural distinctions: ±NEW and ±PROM(INENT). Based on these features, Choi (1999, page 92) defines the four discourse functions shown in Table 10.1: topic, tail, contrastive focus and completive focus.

The feature ±NEW expresses "discourse-newness": that is, information is classified according to how novel it is in the relevant discourse context. Choi analyzes "focused" arguments as being discourse-new (+NEW), while "topic" and "tail" (in the sense of Vallduví 1992) are discourse-old (−NEW). The second feature, ±PROM, refers to the relative prominence that a speaker accords to a particular element in the discourse; it picks out what is "important" or "urgent" in the sentence (Choi 2001, page 21). Under Choi's classification, topic and contrastive focus are prominent (+PROM), while tail and completive focus are non-prominent (−PROM). The analysis in (11) of the answer sentence in (10) exemplifies Choi's feature system:

(10) Q: *What about John? What does he drink?*

A: *John drinks beer.*

(11)	*John*	*drinks*	*beer*.
	TOPIC	TAIL	COMPLETIVE FOCUS
	[−NEW, +PROM]	[−NEW, −PROM]	[+NEW, −PROM]

Choi's (1999) approach has the significant advantage of capturing, for example, what topic and tail have in common: that is, what it means for information to be classed as ground. Under this approach, ground can be defined as that information which has a negative value for the feature NEW. Similarly, topic and contrastive focus form a natural class because they have in common the specification +PROM. This is a crucial advantage over Vallduví's system for Choi because in the German and Korean data which she analyzes, topic and contrastive focus behave alike. Under Vallduví's "atomic" approach to information structure categories, by contrast, the fact that they pattern together like this is surprising: there is no reason to expect that they should have more in common than any two of the other categories. At the same time, under Choi's feature system these two categories are not expected to be identical because they have different values for the other feature NEW: topic is −NEW, while any kind of focus is +NEW.

Table 10.2: Information features and discourse functions according to Butt and King (1996)

	+PROM	−PROM
+NEW	FOCUS	COMPLETIVE INFORMATION
−NEW	TOPIC	BACKGROUND INFORMATION

The binary features originally proposed by Choi in her thesis (published as Choi 1999) were adopted by Butt and King (1996), who also use them to distinguish four information structure roles, though not the same ones as Choi; compare Table 10.1 and Table 10.2. Butt and King (2000) provide the following descriptions of the four discourse functions which they identify as being associated with different phrase structure positions in Hindi-Urdu:

- **TOPIC** is old or known information that is relevant in the current context. In Hindi-Urdu, the TOPIC appears in clause-initial position, in the specifier position of IP.
- **FOCUS** is new and prominent information. It appears in preverbal position in Hindi-Urdu if there is only one focused element; additionally, a phrase may be intonationally marked as focus when it appears in its canonical position.
- **BACKGROUND INFORMATION** is like TOPIC in consisting of old or known information; it provides information as to how new information relates to old information in an utterance. It appears postverbally in Hindi-Urdu.
- **COMPLETIVE INFORMATION** is new information that is not prominent in the discourse. It is not associated with a particular Hindi-Urdu phrase structure position, but occurs preverbally.

In Butt and King's system, completive information is, like focus, new to the addressee, but it differs from focus in terms of its relative significance and hence is classified −PROM. For example, the phrase *in the kitchen* in (12A) is, by their classification, completive information.

(12) Q: *What is Anna reading?*

	She	*is reading*	*War and Peace*	*in the kitchen*.
A:	TOPIC	BACKGROUND	FOCUS	COMPLETIVE
	[−NEW, +PROM]	[−NEW, −PROM]	[+NEW, +PROM]	[+NEW, −PROM]

Background information is comparable to tail in Choi's system. Like completive information, background information is not of great relative significance, but may be a necessary part of the sentence either for syntactic reasons or to further clarify the relation between what is already known and the discourse-new material in the sentence. Topic is classified in the same way by both Choi and Butt and King.

The four-way distinction in information structure roles proposed by Butt and King (1996, 2000) has been adopted by a number of authors in LFG, including Dalrymple and Nikolaeva (2011), Mycock (2013) and Mycock and Lowe (2013). While this four-way distinction suffices for our purposes here, it can be seen to be inadequate given that, for instance, the existence of different types of Topic with different properties (such as Switch Topic and Continuing Topic) is regularly acknowledged in the literature (for example, Choi 1999). One could deal with this by simply proposing an additional information structure feature in order to define a greater variety of information structure roles. However, this requires careful thought: it is not clear where such augmentation of the inventory of information structure features should stop, given that there are a number of subtle information structural distinctions which even an eight-way distinction does not capture. While we do not adopt a more fine-grained approach to information structure roles in this book, we acknowledge that such an approach is ultimately required if we are to account for the full range of information structural distinctions that are attested crosslinguistically. Lowe and Mycock (2014) and Mycock and Lowe (2014) propose a set of four features encoding aboutness, informativeness, discourse newness, and hearer newness. They demonstrate that these features allow principled decompositions of the notions of relative salience and newness, concepts which are often vaguely defined in the wider literature on information structure but which are fundamental to its analysis.

3. REPRESENTING INFORMATION STRUCTURE: EARLY APPROACHES

In this section, we examine previous LFG approaches to the representation of information structure. The earliest approaches utilized the f-structure attributes TOPIC and FOCUS to represent information structure status. Subsequent approaches have represented information structure, or i-structure, as a separate level of grammatical representation.

3.1. Grammaticized Discourse Functions TOPIC and FOCUS

As highlighted in the previous section, the information structure categories of topic and focus have been a central concern in the LFG literature on information structure. Bresnan and Mchombo (1987) discuss the f-structural properties of phrases appearing in sentence-initial position in interrogative and relative clauses in English and other languages (*what* in (13a), *which* in (13b)) with respect to topic and focus roles. They propose that such phrases bear a *grammaticized discourse function* in the f-structure: question phrases in interrogative clauses bear the FOCUS function, and relativized constituents in relative clauses bear the

TOPIC function. Grammaticized discourse functions have also been called *overlay functions*; see Chapter 2, Section 1.11.

(13) a. *I know [*$_{\text{FOCUS}}$ *what you want].*

b. *The car [*$_{\text{TOPIC}}$ *which you don't want] is a Renault.*

Bresnan and Mchombo note that in a cleft construction, the clefted constituent bears both functions: it is the FOCUS in the matrix clause and the TOPIC in the embedded clause, as shown in (14a). They propose that the same constituent cannot bear both the TOPIC and FOCUS functions in the same clause, accounting for the grammaticality judgement assigned to (14b):[5]

(14) a. *It is my car*$_{\text{FOCUS}}$ *[*$_{\text{TOPIC}}$ *that you want].*

b. *??I bought the car [*$_{\text{TOPIC}}$ *that it was* ___$_{\text{FOCUS}}$ *[that you want]].*

3.2. Information Structure Represented in the F-Structure

The grammaticized discourse functions TOPIC and FOCUS proposed by Bresnan and Mchombo have clear syntactic roles and as such are appropriately represented syntactically, in the f-structure. Building on Bresnan and Mchombo's proposals, King (1995), in a key work on information structure, assumes f-structure representations like the following:

(15) F-structure for *Inna, John claimed that he saw* adapted from King (1995, page 199):

$$\left[\begin{array}{ll}
\text{TOPIC} & \left[\text{PRED} \quad \text{`INNA'}\right] \\
\text{PRED} & \text{`CLAIM}\langle\text{SUBJ,COMP}\rangle\text{'} \\
\text{SUBJ} & \left[\text{PRED} \quad \text{`JOHN'}\right] \\
\text{COMP} & \left[\begin{array}{ll}
\text{PRED} & \text{`SEE}\langle\text{SUBJ,OBJ}\rangle\text{'} \\
\text{COMPFORM} & \text{THAT} \\
\text{SUBJ} & \left[\begin{array}{ll}
\text{PRED} & \text{`PRO'} \\
\text{INDEX} & \left[\begin{array}{ll}
\text{PERS} & 3 \\
\text{NUM} & \text{SG} \\
\text{GEND} & \text{M}
\end{array}\right]
\end{array}\right] \\
\text{OBJ} &
\end{array}\right]
\end{array}\right]$$

5 Dalrymple (2010) discusses examples from Malayalam that appear to violate this constraint.

In (15), the phrase *Inna* is displaced from its expected position inside the clausal complement to the beginning of the sentence. At f-structure, *Inna* is both the TOPIC of the clause and the OBJ of the verb *saw*. This sentence therefore exhibits a long-distance syntactic dependency, and is governed by the *Extended Coherence Condition*, first proposed by Zaenen (1980) and discussed in detail by Fassi-Fehri (1988). The Extended Coherence Condition requires the information structural functions TOPIC and FOCUS to be associated with some syntactic function in the f-structure; Bresnan and Mchombo (1987) state the condition as follows:

(16) Extended Coherence Condition:

> FOCUS and TOPIC must be linked to the semantic predicate argument structure of the sentence in which they occur, either by functionally or by anaphorically binding an argument.

Used in this way, the f-structure features TOPIC and FOCUS are grammaticized discourse functions which have a purely syntactic role as overlay functions, consistent with Bresnan and Mchombo's original proposal.

However, the use of the f-structure labels TOPIC and FOCUS was extended in some literature to include not only grammaticized syntactic functions, but also the information structure roles to which those functions are related. For example, King (1995) discusses the Russian example (17), in which the object *den'gi* 'money' bears the role of focus in information structure terms but is not involved in a long-distance dependency and is not syntactically distinguished from other objects. Since at the time no other way of representing information structure roles like topic and focus existed, it was perhaps natural to co-opt the related but different f-structure features TOPIC and FOCUS to represent these information structure roles. King proposes the f-structure in (17) for this sentence:

(17) F-structure for *prislal muž den'gi* according to King (1995, page 212):

prislal	*muž*	*den'gi*
sent	husband	money

'My husband sent (me) the money.'

$$\begin{bmatrix} \text{FOCUS} & \begin{bmatrix} \text{PRED} & \text{`MONEY'} \end{bmatrix} \\ \text{PRED} & \text{`SEND}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`HUSBAND'} \end{bmatrix} \\ \text{OBJ} & \end{bmatrix}$$

When TOPIC and FOCUS are used in this way, f-structure no longer represents only syntactic information; it now includes information structural roles as well. This undermines the principle of modularity that underpins the grammatical architecture of LFG, discussed in Chapter 7, Section 2.[6] This approach to information structure representation was subsequently adopted in other LFG work, predominantly for expediency, it seems, as its inadequacies have been acknowledged in the literature. For example, Butt and King (1996), who discuss information structure and its relation to word order patterns in Urdu and Turkish, use TOPIC and FOCUS to represent information structure topic and focus in f-structure, but note that a separate level of representation for information structure features would be preferable. Likewise, Choi (1999) represents the information structure features ±NEW and ±PROM at f-structure, but expresses similar dissatisfaction.

As noted in Chapter 2, Section 1.11, the inclusion of the attributes TOPIC and FOCUS in f-structure is problematic for other reasons: Alsina (2008) and Asudeh (2004, 2011, 2012) criticize their use in f-structure even for the purely syntactic representation of displaced constituents in long-distance dependencies. Both authors point out that the labels TOPIC and FOCUS have some justification owing to the crosslinguistically widespread connection between displaced phrases in long-distance dependencies and information structural topic or focus status. These labels are, in fact, used in a deliberately ambiguous way in such cases in order to capture a syntactic relation and an information structure relation simultaneously. However, it is not necessarily the case that a particular type of long-distance dependency always involves the same information structure role, and thus collapsing the distinction between the two in this way is undesirable. As an alternative, Alsina proposes the neutral term OP, standing for "operator", in place of both TOPIC and FOCUS, as the f-structure attribute for all displaced elements. Similarly, Asudeh (2004) proposes the single attribute UDF (for "unbounded dependency function"). These terms permit syntactic analyses of those syntactic features that are common to all long-distance dependency constructions without introducing (or apparently introducing) reference to information structure categories. This is a desirable outcome, since there is no necessary one-to-one relation between a particular information structure category and a particular syntactic construction involving a long-distance dependency. For this reason we do not use TOPIC and FOCUS as f-structure attributes, but instead reserve these terms for use solely in relation to information structure. We use the term DIS to represent long-distance dependencies in f-structure in this book. We prefer the use of DIS rather than UDF because the term "unbounded dependency" generally refers to the relation between a filler and a gap, but the feature DIS is also used for the initial constituent in constructions involving left-dislocation and no gap (*Beans, David likes them*). We prefer DIS to OP because the term "operator" is widely used in semantics with a related but different meaning, and we wish to emphasize the syntactic rather than semantic nature of DIS as a syntactic overlay function.

[6]There is also the question of the other constituents' information structure status, for example of *muž* 'husband' and the verb *prislal* 'sent' in (17), which remains unrepresented under such an f-structure approach.

3.3. Information Structure as a Separate Structure

In line with the reservations expressed by Butt and King (1996) and Choi (1999) about the use of f-structure to encode information structure relations, King (1997) provides a series of arguments against such practice. A key issue highlighted by King is the potential for mismatch between f-structure and information structure units, where a particular information structural constituent, such as a topic or focus, does not match a single f-structure constituent, but may match, for example, only part of an f-structure constituent. This is exemplified in the following:

(18) a. *Was it the ex-convict with the red* ***shirt*** *that he was warned to look out for?*

b. *No, it was an ex-convict with a red* ***tie*** *that he was warned to look out for.* (King 1997, page 8, citing Jackendoff 1972, page 232)

(19) F-structure for *ex-convict with a red tie* according to King (1997, page 8):

$$\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{ex-convict}\text{’} \\ \textsc{adj} & \left\{\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{with}\langle\textsc{obj}\rangle\text{’} \\ \textsc{obj} & \left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{tie}\text{’} \\ \textsc{adj} & \left\{\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{red}\text{’} \end{array}\right]\right\} \end{array}\right] \end{array}\right]\right\} \end{array}\right]$$

In this particular exchange, the (contrastive) focus in (18b) is *tie*, which is only part of the value of the OBJ attribute in the f-structure provided; there is no f-structure consisting only of the focused material which can serve as the value of a FOCUS attribute in the f-structure. To solve this problem, King argues for treating information structure as a separate level of the grammar, distinct from f-structure,[7] and makes one of the first explicit formal proposals for such a level. King (1997) proposes the following arrangement of linguistic levels:

(20)

$$\begin{tikzcd} & \text{c-structure} \arrow[dl, dash] \arrow[dr, dash] & \\ \text{f-structure} \arrow[dr, dash] & & \text{i-structure} \arrow[dl, dash] \\ & \text{s-structure} \arrow[d, dash] & \\ & \text{semantics} & \end{tikzcd}$$

King provides the abbreviated partial i(nformation)-structure in (21) for (18b). (Note that the value of BACKGROUND is a set because more than one element can have the status of background information.)

[7]This view is somewhat similar to the proposal of Engdahl and Vallduví (1996) in the Head-Driven Phrase Structure Grammar framework, whereby the features FOCUS and GROUND are represented within a distinct structure called INFO-STRUCT. O'Connor (2006) and Mycock (2006) provide detailed discussions of these issues.

(21) I-structure for example (18b) (King 1997, page 9):

$$\begin{bmatrix} \text{FOCUS} & \text{TIE} \\ \text{BACKGROUND} & \left\{ \begin{array}{c} \text{EX-CONVICT} \\ \text{WITH} \\ \text{RED} \end{array} \right\} \end{bmatrix}$$

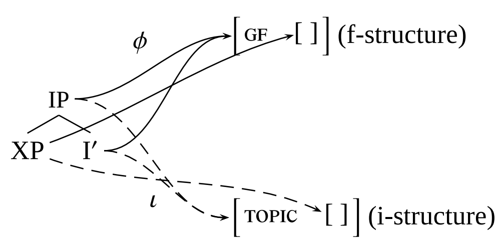
Under King's (1997) proposal, i-structure is represented as an attribute-value structure, just like f-structure. Because it is a separate level of representation, however, its attributes are distinct from those found in f-structure — they are true primitives of information structure rather than a means of capturing facts about the syntax-information structure interface. As a result, the "grouping" of elements in the i-structure may differ considerably from the grouping of the corresponding elements in the f-structure.

Building on King's proposals, and on Butt and King (1996), Butt and King (2000) also discuss the position of i(nformation)-structure as a distinct level of representation within LFG's projection architecture. They propose that i-structure is projected from c-structure independently from the projection of f-structure, as shown in (20). The projection of i-structure from c-structure is defined by the function ι (iota) from c-structure nodes to i-structures, parallel to the function ϕ from c-structure nodes to f-structures. They assume c-structure rules such as the following for Hindi-Urdu:

(22)
$$\text{IP} \longrightarrow \begin{array}{cc} \text{XP} & \text{I}' \\ (\iota(\hat{*})\ \text{TOPIC}) = \iota(*) & \iota(\hat{*}) = \iota(*) \\ (\uparrow \text{GF}) = \downarrow & \uparrow = \downarrow \end{array}$$

This rule states that in Hindi-Urdu an IP dominates a phrase of any category (XP) and an I′ constituent. The XP has some syntactic role at f-structure (GF), and at the same time has the information structure role TOPIC at i-structure. As discussed in Chapter 4, Section 2.1, the IP corresponds to the same f-structure and i-structure as its head, I′. This rule implies the configuration of c-structure, f-structure, and i-structure shown in (23), with the ι function from c-structure nodes to i-structures represented by a dashed arrow:

(23)

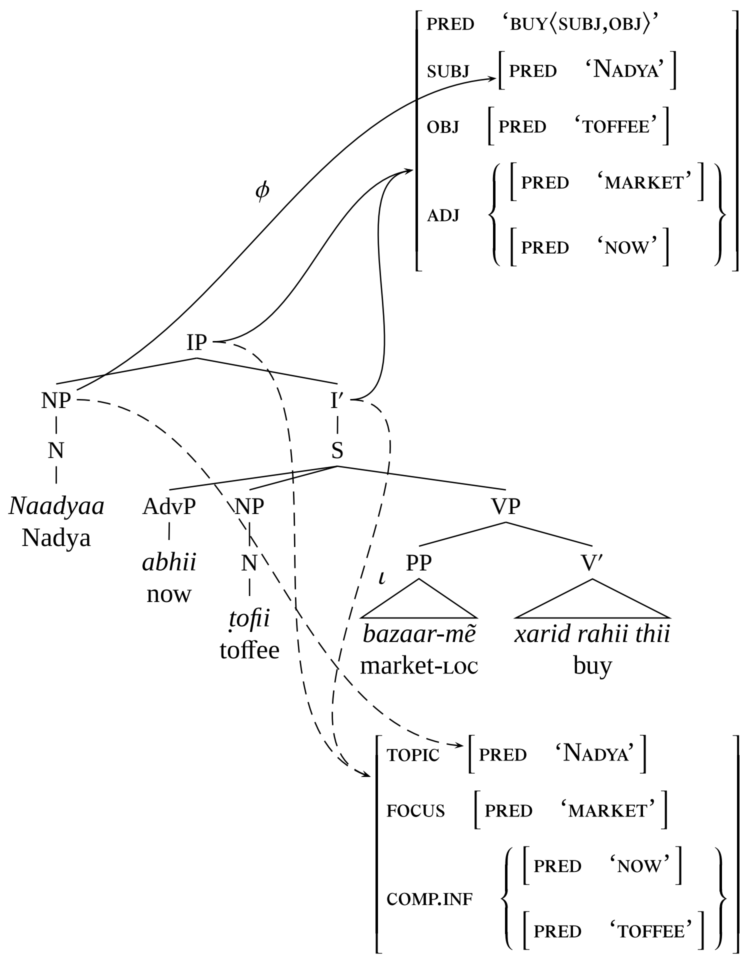


Butt and King (2000) illustrate their proposal by reference to (24) (page 403).[8] Although projected independently from the c-structure, i-structure functions and

[8]The attribute COMP.INF in (24) represents completive information.

(24) I-structure according to Butt and King (2000):

Naadyaa abhii ṭofii bazaar-mẽ xarid rahii thii
Nadya now toffee market-LOC buy stative.F.SG be.PST.F.SG
'Nadya was buying toffee at the market just now.'



f-structure functions are not entirely dissociated from each other. The structures in (23) respect the Extended Coherence Condition given in (16), since the i-structure TOPIC *Naadyaa* has the grammatical function SUBJ at f-structure, and the i-structure FOCUS *bazaar-mẽ* is a member of the ADJ set at f-structure.

Butt and King (2000), like King (1997), assume that i-structure is a projection from c-structure. A similar proposal is made by Mycock (2006), who argues that information structure is directly related to both c-structure and prosodic structure. The shared conception to these proposals is that there is a direct connection between i-structure and c-structure, and a correspondingly indirect connection between i-structure and f-structure. The primary motivation for this view is King's (1997) observation, discussed above, that f-structure constituents often do not correspond to information structure constituents, since f-structures are often either too small or too large to define information structure roles. This is labeled the *granularity problem* by Dalrymple and Nikolaeva (2011, page 92). The analysis of constituent questions proposed by Mycock (2006) raises a similar issue, insofar as it requires reference to units that do not match f-structure constituents, and so cannot be defined in f-structure terms.

The solution to the granularity problem which King (1997) proposed, and which was adopted by Butt and King (2000) and Mycock (2006), is that i-structure is projected directly from c-structure. This overcomes the granularity problem because c-structure is more fine-grained than f-structure. For example, although the f-structure of a modifier is contained within the f-structure of the head, the c-structure nodes of the modifier may map to a different i-structure from that of the head. A direct projection from c-structure to i-structure therefore appears to permit more fine-grained distinctions.

This model of information structure is also adopted by Andréasson (2007), Sulger (2009), and Dione (2012), among others. It is unclear how the theory of s-structure presented in Chapter 8 would be integrated into this approach. S-structure is projected via the σ function from f-structure, but s-structure is also clearly related to i-structure; connecting the two in this model is not straightforward. The model that we propose, described in the next section, overcomes these difficulties by projecting i-structure directly from s-structure, rather than from c-structure. Moreover, this approach is not susceptible to the granularity problem, which was the motivation for assuming a direct connection between c-structure and i-structure in the first place.

4. MODELING INFORMATION STRUCTURE

In this section, we present the formal model of information structure and its relation to other components of the grammar which we assume in the subsequent chapters of this book. The model of information structural representation used in this book is essentially the one presented by Dalrymple and Nikolaeva (2011).

4.1. Overview

Dalrymple and Nikolaeva (2011) adopt King's (1997) view, shared by Butt and King (2000) and many other LFG researchers, that information structure should be treated as a separate level of representation, independent from f-structure. Dalrymple and Nikolaeva propose that information structure contains four attributes, TOPIC, FOCUS, BACKGROUND, and COMPLETIVE, representing the four information structure roles originally proposed by Butt and King (1996), as discussed in Section 2 above. These information structure roles are determined by discourse context, and can be signaled by various different means, such as word order and phrase-structure position.[9] An important feature of their proposal is that the elements categorized at information structure, on the basis of these four features, are *meaning constructors* (see Chapter 8), following Mycock's (2009) insight that information structure and s-structure are closely related.

4.2. Information Structure and its Relation to Semantics

Information structure represents the structuring of the propositional content of an utterance based on the speaker's assumptions about the addressee's state of knowledge at the time of utterance. As it is concerned with the *meaning* of an utterance, it is therefore crucial that a formal theory of information structure should represent the structuring of meanings, and the assignment of information structure roles to meanings, and not, for example, to syntactic elements.

There is no consensus on the relation between truth-conditional semantics and information structure. Some researchers in formal semantics and information structure argue that information structure should be understood and represented as an independent module, separate from the module in which truth-conditional semantics is represented. Others argue that information structure is really a means of partitioning truth-conditional meaning. The approach described here adopts this second view: information structure partitions sentence meaning into information structure categories, as described in Section 4.4 below. In certain respects this approach resembles "structured meaning" approaches (von Stechow 1982; Krifka 2001), and correlates with Lambrecht's (1994) understanding of information structure as the pragmatic structuring of a proposition.

An early proposal for information structure as means of partitioning or "structuring" meanings was made by von Stechow (1982). Von Stechow represents the individual meanings in an utterance as a list, the first element of which represents the topic, and the remaining elements of which represent foci. Krifka (2001) represents utterance meaning as a pair, with background as the first member and focus as the second. Krifka (2006) develops this idea further, proposing a three-part structured meaning for a VP such as 'introduced BILL to Sue' (where 'BILL' has focus status):

[9] More discussion of these issues is provided by Mycock (2006), Erteschik-Shir (2007), Féry and Krifka (2008), and references cited in those works.

(25) Representation of "introduced BILL to Sue"; (Krifka 2006, ex. 2):

$\langle \mathit{Bill}, A, \lambda x.\mathit{introduce}(\mathit{Sue}, x)\rangle$

In (25), the structured meaning is a triple: the first member represents the focus *Bill*, the second member contains a set of alternatives to the focus *A*, and the third member contains the background meaning 'introduced ___ to Sue'. The set of alternatives *A* represents all the relevant individuals that might have been introduced to Sue, including Bill. For example, in the context under consideration *A* might be *{Bill, David, Chris, . . . }*. In a similar way, the approach described here also assumes that meanings of the parts of an utterance are separated and classified according to their information structure roles in context, though the representation used is somewhat different. Although similar to structured meaning approaches, Dalrymple and Nikolaeva (2011) criticize certain assumptions commonly associated with structured meaning approaches to information structure; for example, the transformation of structured meanings into non-structured ("standard") meanings in the presence of "focus-sensitive" operators such as *only* depends on a considerably more restricted view of the structuring of meanings, and plays no part in the analysis that Dalrymple and Nikolaeva propose. Their approach assumes that the information structuring of utterance meaning is relevant for all utterances, regardless of the presence or absence of operators like *only*; in addition, it gives no preferential role to the information structure category of focus, but considers all information structure categories to be relevant to the structuring of meaning.

4.3. Information Structure Categories: the Role of Meaning Constructors

Most treatments of semantic composition in the glue language assume that the meaning constructors appearing in a semantic derivation are undifferentiated and unordered (see Chapter 8). In contrast, Dalrymple and Nikolaeva (2011) argue that meaning constructors are grouped according to information structure role, as in the structured meaning approaches described in the previous section. Thus, meaning constructors that constitute the focus of an utterance are grouped separately from those that constitute the topic, and likewise those that constitute background or completive information are grouped separately. This does not alter in any way the semantic completeness and coherence requirements that are central to the glue framework. That is, an utterance meaning must still be derivable from the complete set of premises contributed by the different parts of the utterance, the utterance meaning should not contain unsaturated expressions, and all contributed meaning constructors must be used in the derivation of the utterance meaning (see Chapter 8, Section 7.1).

In Chapter 8, we discussed in detail the following f-structure and meaning constructors for the sentence *David selected Chris*:

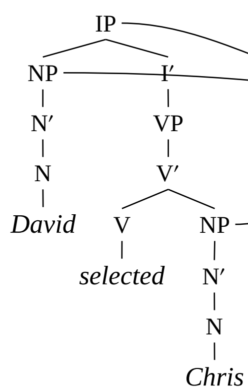
(26)
$$s\begin{bmatrix}\text{PRED} & \text{`SELECT}\langle\text{SUBJ,OBJ}\rangle\text{'}\\ \text{SUBJ} & d\begin{bmatrix}\text{PRED} & \text{`DAVID'}\end{bmatrix}\\ \text{OBJ} & c\begin{bmatrix}\text{PRED} & \text{`CHRIS'}\end{bmatrix}\end{bmatrix}\qquad \begin{array}{l}\mathit{David} : d_\sigma\\ \lambda y.\lambda x.\mathit{select}(x,y) : c_\sigma \multimap [d_\sigma \multimap s_\sigma]\\ \mathit{Chris} : c_\sigma\end{array}$$

As in the previous chapter, these meaning constructors refer to s_σ, d_σ, and c_σ, respectively the semantic structures related by the σ function to the f-structures s, d, and c.

We are now ready to add information structure to the representation. We represent the syntactic, semantic, and information structural aspects of the sentence *David selected Chris* as in (27), given the context Q: *David* constitutes the topic and *selected Chris* constitutes the focus. As more than one meaning constructor may have topic or focus status, the value of each corresponding i-structure attribute is a set.

(27) Q: *What did David do?*

A: $\underbrace{\textit{David}}_{\text{TOPIC}}\ \underbrace{\textit{selected Chris.}}_{\text{FOCUS}}$



$$s\begin{bmatrix}\text{PRED} & \text{`SELECT}\langle\text{SUBJ,OBJ}\rangle\text{'}\\ \text{SUBJ} & d\begin{bmatrix}\text{PRED} & \text{`DAVID'}\end{bmatrix}\\ \text{OBJ} & c\begin{bmatrix}\text{PRED} & \text{`CHRIS'}\end{bmatrix}\end{bmatrix}$$

$$s_{\sigma\iota}\begin{bmatrix}\text{TOPIC} & \{\ \mathit{David} : d_\sigma\ \}\\ \text{FOCUS} & \left\{\begin{array}{l}\lambda y.\lambda x.\mathit{select}(x,y) : c_\sigma \multimap [d_\sigma \multimap s_\sigma]\\ \mathit{Chris} : c_\sigma\end{array}\right\}\end{bmatrix}$$

Here, in addition to the familiar c-structure and f-structure, we see the i-structure, labeled $s_{\sigma\iota}$, which represents the organization of the meaning constructors from (26) according to their status as topic or focus in the context provided.

As noted above, Butt and King (2000) defined a function ι from c-structure nodes to information structures. In contrast, Dalrymple and Nikolaeva (2011) define ι as a function from semantic structures to information structure. In this way i-structure is projected directly from s-structure, and essentially organizes meaning constructors, the building blocks of s-structure, according to i-structure status. An expression like $s_{\sigma\iota}$, which labels the i-structure shown in (27), is defined in terms of the composition of the σ function and the ι function, $\iota \circ \sigma$ (recall our discussion of function composition in Chapter 7, Section 5.1). So, $s_{\sigma\iota}$, which is the i-structure corresponding to s, is obtained by the application of the function σ to an f-structure s, and the subsequent application of the function ι to the s-structure s_σ. In other words, $s_{\sigma\iota}$ can be understood as the i-structure that is projected from the s-structure s_σ by the ι projection function, or, equivalently, as the i-structure which is projected from the f-structure s by the composite projection function $\iota \circ \sigma$. The resulting arrangement of levels is distinct from the arrangement in (20), as this diagram shows:

(28)
$$\begin{tikzcd} \text{c-structure} \arrow[r, "\phi"] & \text{f-structure} \arrow[r, "\sigma"] \arrow[rr, bend right, "\iota\circ\sigma"'] & \text{s-structure} \arrow[r, "\iota"] & \text{i-structure} \end{tikzcd}$$

Using the labels in (29) to represent meaning constructors in a compact and readable way, as we did in Chapter 8, we can represent the semantic proof for sentence (27b) as in (30):

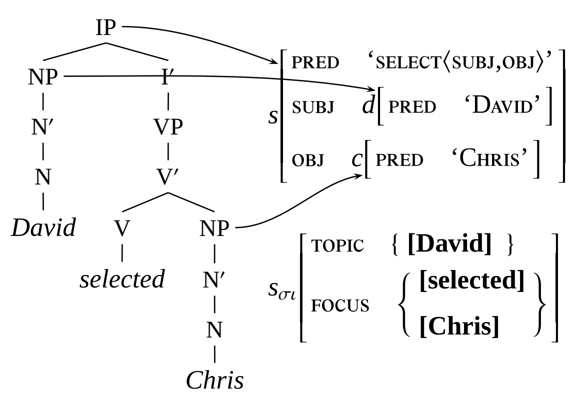
(29)

[David]	$\mathit{David} : d_\sigma$
[Chris]	$\mathit{Chris} : c_\sigma$
[selected]	$\lambda y.\lambda x.\mathit{select}(x, y) : c_\sigma \multimap [d_\sigma \multimap s_\sigma]$
[selected-Chris]	$\lambda x.\mathit{select}(x, \mathit{Chris}) : d_\sigma \multimap s_\sigma$

(30)
$$\dfrac{\dfrac{\textbf{[selected]} \qquad \textbf{[Chris]}}{\textbf{[selected-Chris]}} \qquad \textbf{[David]}}{\mathit{select}(\mathit{David}, \mathit{Chris}) \colon s_\sigma}$$

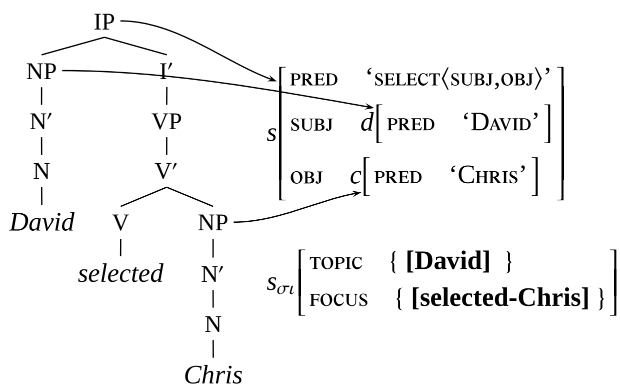
We can also use the labels in (29) to recast the full representation given in (27) in a more reader-friendly format.

(31) *David selected Chris.*



As shown in (30), the meaning constructor **[selected-Chris]** can be deduced via linear logic proof from the two meaning constructors **[selected]** and **[Chris]**. We can therefore represent this configuration equally well as:

(32) *David selected Chris.*



In this representation, meaning constructors are categorized according to their information structure role by virtue of being included in one of the set of values for an s-structure attribute (TOPIC, FOCUS, BACKGROUND, or COMPLETIVE). In (32), the meaning associated with the phrase *David* fills the topic role, while the meaning associated with the phrase *selected Chris* fills the focus role. Meaning constructors contributed by all parts of an utterance are categorized in this way according to their information structure contribution, and appear in the relevant category at i-structure.

4.4. Formal Specification of Information Structure Categories

We now consider how the information structure category of a particular meaning can be specified in formal terms. Dalrymple and Nikolaeva (2011) propose that this specification can be achieved through the use of a special feature at s-structure.

4.4.1. Semantic Structure Features

Liao (2010) proposes the use of features to represent the activation and accessibility of discourse referents in context. The features she uses are adopted from Lambrecht (1994): STATUS, with values IDENTIFIABLE and UNIDENTIFIABLE; ACTV (“activation”), whose values include ACTIVE, ACCESSIBLE, and INACTIVE; and the binary feature ANCHORED. Liao uses these features to analyze the distribution of overt and null anaphora in Mandarin Chinese and to determine information structure roles. Example (33) repeats and augments (88) from Chapter 8 in line with the view that s-structure is the proper level for the representation of these features. In (33) we see the f-structure and meaning constructor for *David* in a context where *David* is identifiable and active in the discourse.

(33) F-structure and meaning constructor for *David*:

$$\begin{bmatrix}\textsc{pred} & \text{`}\textsc{David}\text{'}\end{bmatrix} \dashrightarrow \mathit{David} : \begin{bmatrix}\textsc{animate} & + \\ \textsc{human} & + \\ \textsc{status} & \textsc{identifiable} \\ \textsc{actv} & \textsc{active}\end{bmatrix}$$

The meaning constructor for *David* pairs the meaning *David* with a semantic structure in which an array of semantic and pragmatic features of that meaning are represented; other features and values might be relevant in other contexts (Chapter 8, Section 9).

4.4.2. The Feature DF

The model of information structure presented here depends crucially on an additional s-structure feature, DF (for Discourse Function), whose value is specified by the linguistic context as TOPIC, FOCUS, BACKGROUND, or COMPLETIVE. In a context in which *David* is topical, the associated meaning constructor can be represented as follows:

(34) Meaning constructor for *David*, with specification of information structure role:

$$\mathit{David} : \begin{bmatrix}\textsc{animate} & + \\ \textsc{human} & + \\ \textsc{status} & \textsc{identifiable} \\ \textsc{actv} & \textsc{active} \\ \mathbf{DF} & \mathbf{TOPIC}\end{bmatrix}$$

The value of the DF feature is not specified in the lexical entry for *David* (nor any similar lexical entry, with the possible exception of question words; see Chapter 17, Section 7) since it is not an intrinsic lexical property of *David* that it plays a particular information structure role. Rather, the information structure role of *David* depends, on each occasion of its use, on the linguistic context in which it appears. As discussed in Section 1 of this chapter, information structure roles are determined by the context of utterance; they can be signaled linguistically in a variety of ways, such as by agreement or casemarking, phrasal position, or prosody. It is also possible for information structure roles to be associated by default with particular grammatical functions. For example, in many languages, including English, the subject is the default topic (Dalrymple and Nikolaeva 2011; Bresnan et al. 2016). In this way, any of a number of components of the grammar may determine the DF value of a particular meaning in an utterance.

The relation between the DF feature at s-structure and the categorization of a meaning at i-structure depends on special constraints appearing in lexical entries in Dalrymple and Nikolaeva's model. The lexical entry for *David*, for example, contains at least the following information:

(35) *David* N $(\uparrow \text{PRED}) = \text{`DAVID'}$
$\mathbf{[David]} \in (\uparrow_{\sigma\iota}\ (\uparrow_{\sigma}\ \text{DF}))$

The first line of this lexical entry is entirely familiar. It is the specification in the second line that is crucial for determining the correct information structural configuration. This specification involves the meaning constructor $\mathit{David} : d_{\sigma}$, abbreviated with the label **[David]**. The functional description specifies that this meaning constructor is required to be a member of the set of meaning constructors specified by the value of the s-structure attribute DF. The expression can be paraphrased as follows:

(36) The meaning constructor $\mathit{David} : \uparrow_{\sigma}$, abbreviated as **[David]**, is a member of the set of values, within the information structure $\uparrow_{\sigma\iota}$, of the discourse function attribute signified by $(\uparrow_{\sigma}\ \text{DF})$.

For example, if the value of the semantic feature DF in the s-structure corresponding to $\uparrow_{\sigma}$ is TOPIC, then the meaning constructor must be a member of the TOPIC set at i-structure; see, for example, (32). If the value of DF is specified as FOCUS, then the meaning constructor is a member of the FOCUS set at i-structure, and likewise for BACKGROUND and COMPLETIVE. Thus for any meaning constructor, when a value is specified for the s-structure feature DF, the information structure categorization of that meaning constructor, whether TOPIC, FOCUS, BACKGROUND, or COMPLETIVE, is concurrently specified.[10] If no value is specified for the DF feature, the meaning constructor is not integrated into the information structure of the sentence, and the resulting meaning for the sentence is semantically incomplete, incoherent, or both.

4.4.3. Positional Specification of DF

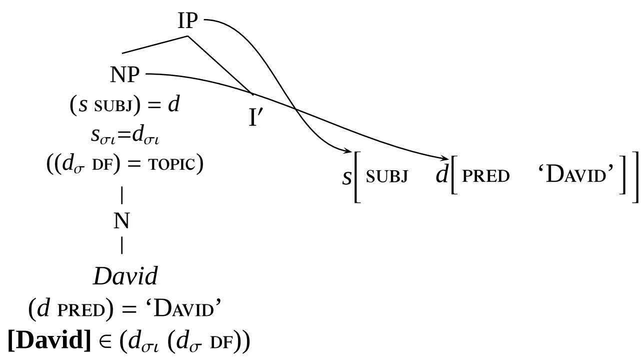
When an information structural role is associated with a particular syntactic position, this information is included in annotated phrase structure rules like the following for English:

(37)
$$\text{IP} \longrightarrow \begin{array}{c} \text{NP} \\ (\uparrow \text{SUBJ}) = \downarrow \\ \uparrow_{\sigma\iota} = \downarrow_{\sigma\iota} \\ ((\downarrow_{\sigma}\ \text{DF}) = \text{TOPIC}) \end{array} \quad \begin{array}{c} \text{I}' \\ \uparrow = \downarrow \\ \\ \\ \end{array}$$

In the sentence *David selected Chris*, *David* is the subject, appearing in the specifier of IP. As mentioned previously, there is a well-known default relationship between the grammatical function subject and the information structural role topic. This is captured by the phrase structure rule in (37) combined with a lexical entry like (35). Taking the two together, we obtain the following partial configuration, representing here only the c-structure and f-structure:

[10] The way in which this is specified is similar to the use of the PCASE feature in the specification of the grammatical role of a prepositional phrase; see Chapter 6, Section 2.

(38)



In the annotations under the phrase structure nodes and in the lexical entry in (38), the ↑ and ↓ metavariables have been instantiated to the f-structure names *s* and *d*. The ↑ =↓ annotation on N, which ensures that the NP and its head *David* correspond to the same functional structure, has been left implicit. The arrows represent the familiar ϕ function from c-structure nodes to f-structures. In the following exposition we omit the c-structure in the interests of readability, retaining only the functional descriptions harvested from the annotated c-structure. The full f-description obtained from the c-structure in (38) is:

(39)

$$\begin{array}{ll} (s\ \textsc{subj}) = d & \\ s_{\sigma\iota}{=}d_{\sigma\iota} & \\ ((d_\sigma\ \textsc{df}) = \textsc{topic}) & s\left[\textsc{subj}\quad d\left[\textsc{pred}\quad \text{`David'}\right]\right] \\ (d\ \textsc{pred}) = \text{`David'} & \\ \textbf{[David]} \in (d_{\sigma\iota}\ (d_\sigma\ \textsc{df})) & \end{array}$$

The first line of (39) requires the f-structure *d* to be the subject of *s*, which is true for the f-structure shown. The second line is crucial: it requires the information structure corresponding to *s* and *d* to be the same. All nonhead daughters in the phrase structure rules of a language bear such a specification, ensuring that all members of a clause share the same information structure.[11]

The third line provides the optional, default discourse function TOPIC associated with the subject. If its discourse function is not otherwise specified, and as long as compatible specifications are provided by the linguistic context (as discussed below), and the prosodic and discourse prominence features of *David* are consistent with the topic role, then the subject is associated with the i-structure role TOPIC.

The fourth line is contributed by the lexical entry for *David*, and requires that the subject f-structure, *d*, have a feature PRED with value 'DAVID'. Again, this is true for the f-structure in (39). The fifth line, also contributed by the lexical

[11] Heads need not be explicitly marked with this specification. The head of a phrase corresponds to the same f-structure as the mother node according to the Head Convention (Chapter 4, Section 2.1). Therefore, since s-structure is projected from f-structure, and i-structure is projected from s-structure, a phrase and its head correspond to the same f-structure, s-structure, and i-structure.

entry, specifies that the meaning constructor **[David]** must bear the role specified by $(d_\sigma\ \textsc{df})$ at i-structure, as discussed above.

If we assume that the default equation $((d_\sigma\ \textsc{df}) = \textsc{topic})$ holds, we can simplify the final line of these constraints as follows, according to the equality $s_{\sigma\iota}{=}d_{\sigma\iota}$:

(40)

$$
\begin{array}{l}
(s\ \textsc{subj}) = d \\
(d_\sigma\ \textsc{df}) = \textsc{topic} \\
(d\ \textsc{pred}) = \text{‘}\textsc{David}\text{’} \\
\textbf{[David]} \in (s_{\sigma\iota}\ \textsc{topic})
\end{array}
\qquad
\begin{array}{l}
s\left[\textsc{subj}\quad d\left[\textsc{pred}\quad \text{‘}\textsc{David}\text{’}\right]\right] \\[1ex]
d_\sigma\left[\textsc{df}\quad \textsc{topic}\right] \\[1ex]
s_{\sigma\iota}\left[\textsc{topic}\quad \{\ \textbf{[David]}\ \}\right]
\end{array}
$$

The equations produce the configuration shown:

- at f-structure, the subject of s is d, and d’s $\textsc{pred}$ is ‘$\textsc{David}$’;
- the s-structure d_σ corresponding to d has the feature $\textsc{df}$ with value $\textsc{topic}$;
- the value of the attribute $\textsc{df}$ for d_σ specifies the $\textsc{topic}$ attribute in the i-structure for the clause, $s_{\sigma\iota}$.

It is in this way that meaning constructors are specified as bearing a particular information structure role in the particular linguistic context in which they appear.

4.4.4. An Example

A more complete set of phrase structure rules for a simple English clause is:

(41)

$$
\begin{array}{lll}
\text{IP} & \longrightarrow & \begin{array}{c}\text{NP}\\ (\uparrow \textsc{subj}) = \downarrow\\ \uparrow_{\sigma\iota}{=}\downarrow_{\sigma\iota}\\ ((\uparrow_\sigma\ \textsc{df}) = \textsc{topic})\end{array} \quad \begin{array}{c}\text{I}'\\ \uparrow=\downarrow\\ \\ \\ \end{array} \\[2ex]
\text{I}' & \longrightarrow & \left(\begin{array}{c}\text{I}\\ \uparrow=\downarrow\end{array}\right) \quad \begin{array}{c}\text{VP}\\ \uparrow=\downarrow\end{array} \\[2ex]
\text{VP} & \longrightarrow & \begin{array}{c}\text{V}'\\ \uparrow=\downarrow\end{array} \\[2ex]
\text{V}' & \longrightarrow & \begin{array}{c}\text{V}\\ \uparrow=\downarrow\\ \\ \end{array} \quad \left(\begin{array}{c}\text{NP}\\ (\uparrow \textsc{obj}) = \downarrow\\ \uparrow_{\sigma\iota}{=}\downarrow_{\sigma\iota}\end{array}\right)
\end{array}
$$

We are now able, using these rules, to model the information structure of a sentence such as *David selected Chris* in (27). The annotations on these rules should be familiar and unremarkable, except for the annotation $\uparrow_{\sigma\iota}{=}\downarrow_{\sigma\iota}$ on the NP daughter of V′, which specifies that the object’s information structure is the same as the information structure for the entire utterance. We augment the lexical entries for *selected* and *Chris* with the requirement for their meaning constructors to bear an information structure role: they are required to be a member of some set of meaning constructors at i-structure, the set determined by the value of the attribute DF at s-structure.

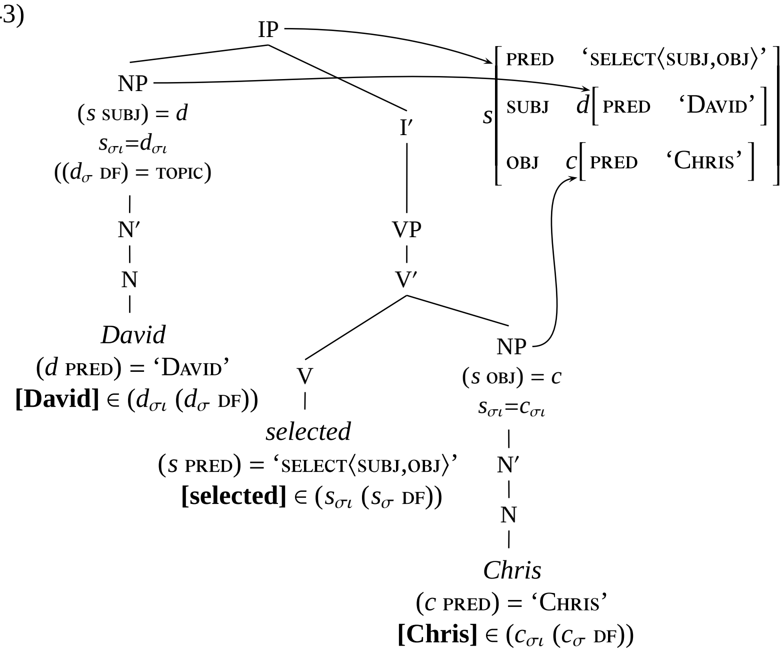
(42) *selected* V $(\uparrow \text{PRED}) = \text{`SELECTED}\langle\text{SUBJ,OBJ}\rangle\text{'}$
$\textbf{[selected]} \in (\uparrow_{\sigma\iota}\ (\uparrow_{\sigma}\ \text{DF}))$

Chris N $(\uparrow \text{PRED}) = \text{`CHRIS'}$
$\textbf{[Chris]} \in (\uparrow_{\sigma\iota}\ (\uparrow_{\sigma}\ \text{DF}))$

In addition, we require the information structure roles of *David*, *selected* and *Chris* to be specified. This can be achieved in a number of ways, through syntactic encoding or as a result of the discourse context, for example. For this particular sentence, we assume that the discourse context identifies *David* as topical, reinforcing the default specification in the phrase structure rule for IP that the subject is the topic. We also assume that the phrase *selected Chris* has focus status, based on its context as the answer to the question *What did David do?*.[12] The c-structure and f-structure for the sentence *David selected Chris*, including annotations relevant for the formation of information structure, is given in (43) on page 415.

[12]The discourse prominence features and prosodic contour must reinforce these assignments, or at least must not conflict with the assignment of these roles. The contribution of prosody is explored in Chapter 11. As yet there exists no widely agreed LFG model of how discourse context contributes to the determination of information structure roles.

(43)



Contribution from linguistic and pragmatic context: (d_σ DF) = TOPIC
(s_σ DF) = FOCUS
(c_σ DF) = FOCUS

Again, we harvest the functional description from the annotated c-structure in (43). In (44), the constraints are reordered and categorized for ease of reference, separated into those that refer only to the f-structure, those that refer to s-structure, and those that are relevant for i-structure. The f-structure is specified by the constraints under (A); the constraints under (B) specify DF values at s-structure; and the constraints under (C) define the i-structure for this utterance on the basis of the DF specifications. (The equation specifying *David* as TOPIC, which is both optionally specified on the phrase structure rule and reinforced by the context, has not been repeated.)

(44) (A) $(s\ \textsc{pred}) = \text{`}\textsc{select}\langle\textsc{subj},\textsc{obj}\rangle\text{'}$
$(s\ \textsc{subj}) = d$
$(d\ \textsc{pred}) = \text{`}\textsc{David}\text{'}$
$(s\ \textsc{obj}) = c$
$(c\ \textsc{pred}) = \text{`}\textsc{Chris}\text{'}$

$$s\begin{bmatrix} \textsc{pred} & \text{`}\textsc{select}\langle\textsc{subj},\textsc{obj}\rangle\text{'} \\ \textsc{subj} & d\begin{bmatrix}\textsc{pred} & \text{`}\textsc{David}\text{'}\end{bmatrix} \\ \textsc{obj} & c\begin{bmatrix}\textsc{pred} & \text{`}\textsc{Chris}\text{'}\end{bmatrix} \end{bmatrix}$$

(B) $(d_\sigma\ \textsc{df}) = \textsc{topic}$ $\quad d_\sigma : \begin{bmatrix}\textsc{df} & \textsc{topic}\end{bmatrix}$
$(s_\sigma\ \textsc{df}) = \textsc{focus}$ $\quad s_\sigma : \begin{bmatrix}\textsc{df} & \textsc{focus}\end{bmatrix}$
$(c_\sigma\ \textsc{df}) = \textsc{focus}$ $\quad c_\sigma : \begin{bmatrix}\textsc{df} & \textsc{focus}\end{bmatrix}$

(C) **[David]** $\in (d_{\sigma\iota}\ (d_\sigma\ \textsc{df}))$
[selected] $\in (s_{\sigma\iota}\ (s_\sigma\ \textsc{df}))$
[Chris] $\in (c_{\sigma\iota}\ (c_\sigma\ \textsc{df}))$
$s_{\sigma\iota}{=}d_{\sigma\iota}$
$s_{\sigma\iota}{=}c_{\sigma\iota}$

As above, we simplify the equations in (C), using the equalities in (B) and in the last two lines of (C), to produce a compact description of the information structure for this utterance:

(45) (C) **[David]** $\in (s_{\sigma\iota}\ \textsc{topic})$
[selected] $\in (s_{\sigma\iota}\ \textsc{focus})$
[Chris] $\in (s_{\sigma\iota}\ \textsc{focus})$

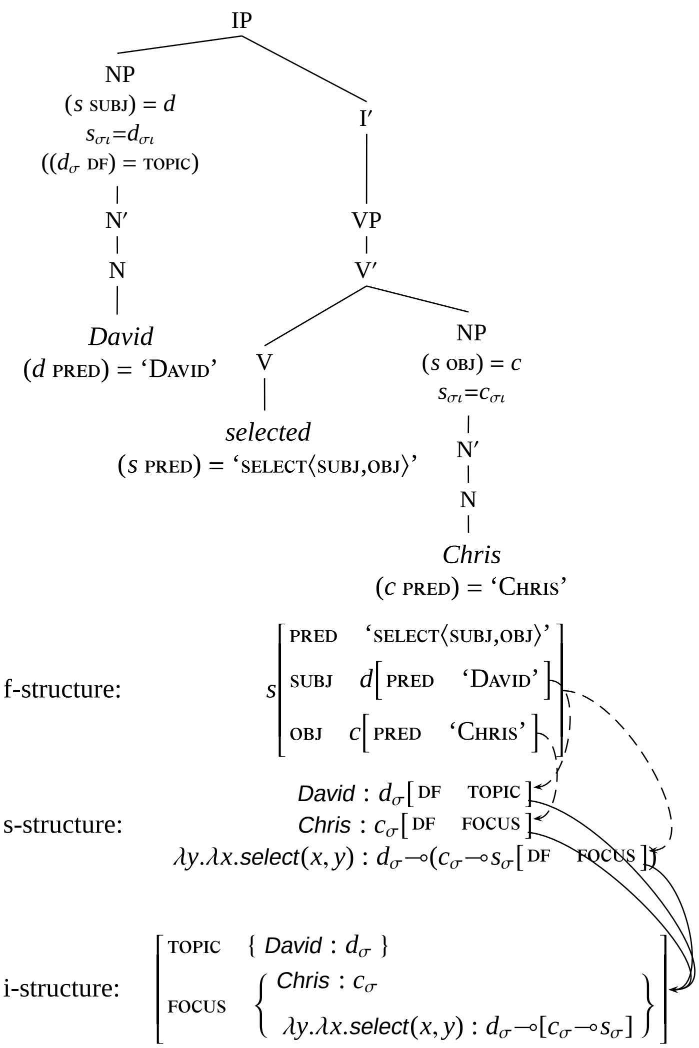
$$s_{\sigma\iota}\begin{bmatrix} \textsc{topic} & \{\ \textbf{[David]}\ \} \\ \textsc{focus} & \left\{\begin{matrix}\textbf{[selected]} \\ \textbf{[Chris]}\end{matrix}\right\} \end{bmatrix}$$

Since **[selected-Chris]** can be derived by linear logic proof from **[selected]** and **[Chris]** (as shown in the proof in 30), we can, once again, simplify this further to:

(46)
$$s_{\sigma\iota}\begin{bmatrix} \textsc{topic} & \{\ \textbf{[David]}\ \} \\ \textsc{focus} & \{\ \textbf{[selected-Chris]}\ \} \end{bmatrix}$$

Example (47) is an augmented version of the diagram in (43), showing the full configuration and relationships between structures. The dashed arrows represent the σ function from f-structure to s-structure, while the solid arrows represent the ι function from s-structure to i-structure:

(47)



We see in this diagram that this clause has a single i-structure in which meaning constructors are classified according to their information structure role. This i-structure is formed on the basis of information in the s-structures corresponding to individual meaning constructors. For instance, the discourse function value TOPIC in the s-structure corresponding to *David* ensures that the relevant meaning constructor is a member of the TOPIC set at i-structure (in this case, the only member).

4.4.5. GRANULARITY AND I-STRUCTURE ROLE

Dalrymple and Nikolaeva's (2011) approach to information structure, which we have explored in this chapter, is not susceptible to the granularity problem as it was presented in Section 3.3. Approaches that use f-structure units to specify information structure roles fail due to the granularity problem, since reference to the contents of an f-structure necessarily includes reference to any arguments and modifiers that appear in that f-structure (King 1997). In the approach of Dalrymple and Nikolaeva (2011), on the other hand, the specification of a particular information structure role for a head does not entail that everything within the same f-structure is associated with that role. Rather, only the meaning constructors contributed by the head or heads of the f-structure are associated with the specified information structure role. For instance, in (47), the meaning constructor associated with the verb appears in the FOCUS set at information structure. This does not entail, however, that the arguments of the verb must also appear in the FOCUS set. Indeed, in (47) the subject of the verb is not (part of) the focus but is the topic, and accordingly appears in the TOPIC set at i-structure.

One consequence of Dalrymple and Nikolaeva's approach is that every meaning constructor associated with a clause must bear a particular role at i-structure, that is, each one must appear in the set value of one of the information structure categories. In the Dalrymple and Nikolaeva model, this is enforced by requiring that every meaning constructor is associated with an equation of the following form:

(48) **[meaning-constructor]** $\in (\uparrow_{\sigma\iota}\ (\uparrow_{\sigma}\ \textsc{df}))$

This equation states that the meaning constructor must appear in the i-structure set which is specified by the value of $(\uparrow_{\sigma}\ \textsc{df})$. Very often, this value is not specified grammatically, but is determined by the linguistic and discourse context. Even in cases where the value of $(\uparrow_{\sigma}\ \textsc{df})$ is not grammatically specified, the equation in (48) requires a value to be found. In this way, all meaning constructors play a role at i-structure. This contrasts with claims that some elements can be entirely excluded from information structure. For example, Kwon and Zribi-Hertz (2008) assume that certain unmarked subjects and objects in Korean have no information structure role. In Dalrymple and Nikolaeva's model, such an analysis is impossible: all parts of an utterance meaning are categorized at information structure. Information structure does not simply pick out certain parts of a sentence and specify particular roles for them, therefore, but partitions the entire sentence meaning according to the relevant criteria.

5. FURTHER READING AND RELATED ISSUES

Hong (1991), King (1997), Lowe and Mycock (2014), and Mycock and Lowe (2014) discuss information structure and its place in the overall architecture of LFG. King and Zaenen (2004) and O'Connor (2006) provide a useful overview of information structure within LFG. More specific works on information structural issues in different languages include Dahlstrom (2003) on focus constructions in Meskwaki, Cook and Payne (2006) on the relevance of information structure to distributive scope in German, Andréasson (2007) on word order in Swedish, Mayer (2008) on differential object marking in non-standard Limeño Spanish contact varieties, Sulger (2009) on cleft constructions in Irish, Dione (2012) on cleft constructions in Wolof, and Zymla et al. (2015), who develop a computationally grounded model of the Common Ground in their treatment of German modal particles.

As noted above, in this chapter we have concentrated exclusively on the organization of information within clauses. A more complete model would, of course, also account for the structuring and organization of information across clauses and the effect that this can have on other aspects of linguistic structure. Little work currently exists in LFG on discourse structure (that is, cross-clausal information structuring); King and Zaenen (2004) and Gazdik (2011) are exceptions.

11

PROSODIC STRUCTURE

In this chapter, we investigate the relationship between the phonological or prosodic structure of a spoken utterance and its syntactic, semantic, and information structural analysis. A full theory of the form-meaning correspondence must account for the effect of prosodic features such as intonation patterns on interpretation. Work in LFG that is concerned with the contribution made by phonology or prosody to grammatical structure and interpretation usually assumes the existence of a separate *prosodic structure* (sometimes called *phonological structure*) within the overall grammatical architecture. We will review previous LFG approaches to prosody and the place of prosodic structure within the grammar, before presenting and exemplifying the approach that we adopt.

1. PROSODY AND GRAMMAR

Prosody refers to the patterns of rhythm and intonation in spoken language. Prosodic (also referred to as suprasegmental) features of speech are acoustic characteristics associated with a particular phonological domain. The relevant features are generally assumed to be pitch, length, and loudness; their physical correlates are fundamental frequency (F0, measured in Hz), duration, and intensity (measured in dB), respectively. Our concern here is with prosody at the sentence level; we are interested in word-level prosody insofar as it interacts with sentence-level prosody. Reflecting the vast majority of research in LFG, the data we consider in this chapter will overwhelmingly focus on patterns of intonation and the analysis of F0; for LFG work that considers duration and pitch as well, see Bögel (2015, Chapter 3).

The approach that we adopt in this book, in line with the majority of work in LFG on the interface between intonation and the other aspects of linguistic structure discussed in Part II, is a phonological model of intonation designed to capture generalizations about this system and its meaningful contrastive elements.[1] Under such a model, contours are analyzed as melodies, abstracting away from their precise shape and the specific Hz values with which they are produced. This kind of model is inherently flexible with respect to the relationship between prosody and other aspects of linguistic structure. This is a necessary condition if the model is to account for the attested variability in intonation that can relate to factors such as speech rate, speaker, style, and dialect, inter alia (see, for example, Arvaniti and Ladd 2009; Arvaniti 2016). For a general introduction to phrasing and intonation, which also includes data referred to in this chapter, see Hayes and Lahiri (1991).

The central concerns of a theory of the relation between prosody and other parts of the grammar are the understanding and analysis of the relation between the phonological features of a word or utterance and its abstract grammatical properties. It is clear enough, for example, that some connection must exist between the phonological realization of a word and the c-structural, f-structural and s-structural features and structures that correspond to that phonological realization. However, the precise nature of that connection and how it is constrained are less clear. The problem is particularly acute above the word level: how is a particular phonological or prosodic domain related to a particular syntactic or semantic unit?

This is not merely a matter of incorporating an additional, ancillary aspect of linguistic analysis into an otherwise complete model of grammar. Prosodic features such as pitch and duration can, and very often do, make crucial contributions to the interpretation of an utterance. For example, in Japanese a question is distinguished from a declarative sentence in writing by the presence of a sentence-final particle such as *ka*. In spoken Japanese, the inclusion of this particle is optional (Hinds 1986); what is critical is the intonation pattern that is used. If the version of (1) without *ka* is spoken with a final fall in intonation, the utterance is interpreted as a declarative; if there is a final rise in intonation, it is interpreted as a yes-no question. In the latter case, the contribution to meaning that prosody makes effectively “overrides” the apparently unambiguous declarative syntax of the sentence. This means that the pitch movement associated with the end of the utterance is crucial to the interpretation of (1) when it does not include

[1] Bögel’s (2012; 2013; 2014; 2015) p-diagram approach, grounded in details of the speech signal, represents an alternative approach within the LFG framework; this is briefly discussed in Section 7.

the question particle. Such data illustrate how prosody can make an independent contribution to meaning.

(1) *Norio-ga Mayumi-ni omocha-o erabimashita (ka)*
Norio-NOM Mayumi-DAT toy-ACC choose.PST Q
'Did Norio choose a toy for Mayumi?'

We represent intonational contours, which may also be referred to as melodies or tunes, using two abstract tone specifications: High (H) and Low (L). For example, our representation of the final falling declarative intonational contour in Japanese is shown in (2a) as a High tone preceding a Low tone, while the final rising intonational contour associated with the interrogative reading of (1) is represented in (2b) as the sequence Low–High.

(2) a. *Norio-ga Mayumi-ni omocha-o erabimashita.*
H L

b. *Norio-ga Mayumi-ni omocha-o erabimashita?*
L H

Prosody may also be used to resolve ambiguity. For example, it has been claimed that differences in prosodic phrasing can be used to distinguish between candidate syntactic structures, though speakers in general do not do this consistently (see, for instance, Allbritton et al. 1996). Consider the following examples, taken from Price et al. (1991), in which square brackets delimit the subordinate clause, and parentheses indicate the prosodic constituency that can be associated with each reading. Note how the boundaries of the two types of constituents coincide.

(3) *When you learn gradually you worry more.*

a. Reading 1: When you learn gradually, you worry more than when you learn quickly.
= ([When you learn gradually]) (you worry more)

b. Reading 2: When you learn, you gradually begin to worry more.
= ([When you learn]) (gradually you worry more)

Which of the two syntactic analyses is preferred may depend upon the location of cues such as pauses which signify boundaries between prosodic constituents: when a pause occurs after *gradually*, the interpretation is the one given in (3a), i.e. *gradually* modifies the verb *learn* in the subordinate clause; when a pause occurs after *learn*, the interpretation is the one given in (3b), i.e. *gradually* is part of the main clause. Such data indicate that a close relationship can exist between prosodic phrasing and syntactic structure (though one should be cautious about claiming that disambiguation is the result of a one-to-one relationship between the two). Furthermore, they demonstrate the importance of integrating prosody into any account of the form-meaning relation.

Debate in the literature on prosody has centered on one fundamental issue in particular, which we too must address before presenting the approach that we adopt, namely whether the phonological/prosodic component is an independent module with its own internal structure.

2. PROSODY: AN INDEPENDENT LEVEL OF STRUCTURE?

At the heart of the debate on the place of prosody in the grammar is the issue of its relation to syntactic structure. Specifically, the question is whether phonological processes make *direct reference* to syntactic information or *indirect reference* via an interface relation, the nature of which must be identified and defined.

2.1. Direct versus Indirect Reference

Support for the direct reference approach comes from data which indicate that phonological output is defined on the basis of syntactic structure, as one might argue is the case in (3). This information is generally assumed to concern syntactic constituency (for example Kaisse 1985; Odden 1995) but could in principle refer to other types of syntactic relation, as Pak (2008) points out. Such an approach to the syntax-phonology interface is problematic on a view which regards syntax and phonology as fundamentally distinct. For instance, Scheer (2011, page 347) holds that syntax and phonology are separate aspects of linguistic structure and as such are each unable to interpret units, features, and structures specific to the other.

Even setting aside this incompatibility, the direct reference approach has been criticized in the light of data which show that syntactic and prosodic structure are not, as one would predict under such a model, necessarily isomorphic; for discussion of relevant data, see Chen (1987), Selkirk and Shen (1990), and Bošković (2001). Lahiri and Plank (2010) seek to emphasize, based on observations about Germanic languages that date back at least to Steele (1775/1779), that the prosody-syntax relation is in fact characterized by extensive misalignment; a lack of isomorphism between the two is more the rule than the exception (see example 12).

The alternative to direct reference is an indirect reference approach, according to which an interface relation serves to connect the syntax and phonology macromodules. An indirect reference approach copes well with data which demonstrate a lack of isomorphism between syntactic and prosodic structure. While the two are systematically related to one another via a mapping algorithm, under such an approach there is no expectation that isomorphism is the result. With respect to modularity and domain specificity, the distinction between syntax and prosody can be maintained by assuming indirect reference: the objects and structures native to one module cannot be interpreted or manipulated by the other module.

An indirect reference approach to the syntax-prosody interface is not by definition restricted to one particular theoretical framework, but it clearly fits well with the parallel grammatical architecture and general commitment to modular specificity of LFG (Chapter 7, Section 2). Of course, such an approach requires an independent level of representation with its own primitives and organizing principles, which provides the domains of application relevant to postlexical phonological processes. The issue of precisely how to define and represent prosodic structure continues to be the subject of research and debate in the wider literature. In the following section, we review the ideas which have been most influential in the modeling of prosody and its interfaces within the LFG framework.

2.2. Units, Constraints, and Internal Structure

Early work on the representation of prosodic features in generative phonology, for example by Chomsky and Halle (1968), assumed binary features such as [±STRESS]. Such features could be assigned to particular syllables by rules applied in particular phonological contexts, but no cohesive theory existed of the prosodic structure of whole phrases or utterances. Building on earlier work by Liberman (1975) and Liberman and Prince (1977), which explored hierarchical structure in phonology at the level of the word and below, Selkirk (1978, 1980a,b, 1981) first proposed that the phonological or prosodic features of phrases and utterances could be described by reference to a structured prosodic representation. Under this "Prosodic Phonology" approach, developed further by Nespor and Vogel (1986), an utterance can be analyzed not only in terms of hierarchical syntactic structure, i.e. constituent structure, but also in terms of hierarchical *prosodic structure*.

According to Prosodic Phonology, the categories of prosodic structure are, like the categories of constituent structure, finite in number and available crosslinguistically. In contrast to constituent structure, prosodic phrases are not projected by a head, but are related to one another according to the Prosodic Hierarchy. The precise inventory of categories which form the Prosodic Hierarchy varies in the literature (as does the inventory of constituent structure categories, as discussed in Chapter 3); we assume the inventory and set of hierarchical relations shown in (4), taken (with modified labels) from Selkirk (1995), with these units being defined independently of units at any other level such as c-structure. Much research has investigated the units of the Prosodic Hierarchy, focusing on prosodic/phonological phenomena that have these units as their domain, and the associated prosodic features which can be taken as cues for their detection.[2]

[2]For an interesting critical review of the Prosodic Hierarchy and Prosodic Phonology in general, see Scheer (2011).

(4) The Prosodic Hierarchy:

Utterance (Utt)
|
Intonational Phrase (IntP)
|
Phonological Phrase (PhP)
|
Prosodic Word (PW)
|
Foot (Ft)
|
Syllable (S)

The *syllable* is the smallest unit of the Prosodic Hierarchy that is of concern to us.[3] In many languages, syllables are the smallest units with which certain phonological features, such as stress, are associated.[4] A *foot* is a prosodic constituent consisting of one or more syllables. Patterns in the alternation of stressed and unstressed syllables in languages such as English are often stated by reference to rules of foot formation. One or more feet make up a *prosodic word*. Feet are crucial in the formation of prosodic words, but beyond this the foot is not relevant for the purposes of modeling prosody's interfaces with other modules of the grammar. (For this reason, and in the interests of clear presentation, the foot level is omitted in the analyses of prosodic structure which we present in this book.) Prosodic words are usually assumed to be the domain within which lexical phonological processes, and often other processes such as cliticization, apply. One or more prosodic words make up a *phonological phrase*, the unit within which a single prosodic contour may apply. The *intonational phrase* consists of one or more prosodic phrases. This is the unit within which the smaller prosodic contours of prosodic phrases are subject to larger overarching processes, such as the gradual declination of median pitch; the boundaries of intonational phrases are therefore generally characterized by pitch reset. Finally, the *utterance* is the largest prosodic constituent, comprising any single unit of continuous speech consisting of one or more intonational phrases.[5]

As with constituent structure, it is possible to state rules or constraints on the formation of valid prosodic structures. These constraints (see Selkirk 1984 for details) are usually subsumed under the "Strict Layer Hypothesis" (Nespor and Vogel 1986, page 7; Selkirk 2011, page 437), which constitutes a general well-formedness condition on prosodic structure. The Strict Layer Hypothesis re-

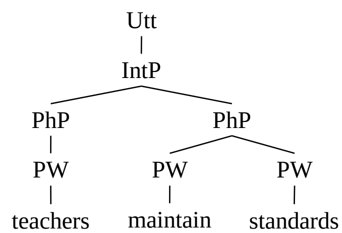
[3]Syllables consist of one or more morae, the smallest prosodic units, but we will not make reference to morae here. Morae themselves are analyzed as consisting of smaller phonological units, *segments* and *features*, units which are generally considered to be sub-prosodic.

[4]As it is not our intention to provide a comprehensive introduction to prosody and phonology, we set aside the issue of precisely how stress should be defined. For an overview, see Fox (2000).

[5]There are many alternative definitions of these prosodic constituents. See for example Selkirk (1978), Nespor and Vogel (1986), Levelt (1989), Wheeldon (2000) and Frota (2012). As stated previously, we seek to define these constituents in purely prosodic terms, whereas many of these authors define them in a combination of syntactic and prosodic terms.

quires that an utterance be parsed exhaustively into non-recursive prosodic constituents, which form “layers” that correspond to categories of the Prosodic Hierarchy. Thus, an Intonational Phrase (IntP) can immediately dominate only Phonological Phrases (PhPs), and a PhP can immediately dominate only Prosodic Words (PWs).[6] For example:

(5)



The basic approach to prosodic structure illustrated by (5) is widely assumed in LFG approaches to postlexical phonological processes, though the hierarchical structuring of prosodic constituents has not always been represented as a tree structure, as we will see.

3. REPRESENTING PROSODIC STRUCTURE IN LFG: EARLY APPROACHES

Early work in LFG made no attempt to integrate a theory of prosody or its relation to the syntactic component of grammar. The first significant steps in this direction were made by Butt and King (1998), who made an explicit proposal regarding the LFG representation of prosodic features relevant to syntax. Butt and King (1998) propose a p(honological)-structure, projected from c-structure and parallel to but separate from f-structure. Butt and King’s phonological structure encodes only phonological information that is relevant to the syntax and can contribute to the full interpretation of an utterance. Butt and King (1998) illustrate their proposals with reference to ambiguous verb phrases in Bengali such as this sentence from Hayes and Lahiri (1991):

(6) *ami b^{h}ut dek^h-l-am.*
I ghost see-PST-1SG
a. ‘I was startled.’ (idiomatic reading)
b. ‘I saw a ghost.’ (literal reading)

When spoken, the two readings of the sentence in (6) are associated with different phrasings: the idiomatic reading ‘was startled’ is licensed when the VP

[6] This strict view of the constraints on prosodic domination has been called into question by a number of authors, including Inkelas (1989) and Itô and Mester (2003). In particular, it has been noted that exhaustivity and the bar on recursivity may be best viewed as tendencies, given that they can be violated in a number of languages. For a recasting of the Strict Layer Hypothesis in Optimality-Theoretic terms that takes this into account, see Selkirk (1995). Bögel (2015) provides an alternative approach within LFG which explicitly avoids the prosodic hierarchy as a basis for prosodic structure.

corresponds to a single PhP (7a), while the literal reading 'saw a ghost' emerges when the verb form and *b^h^ut* 'ghost' constitute two distinct PhPs (7b), as indicated by the labeled brackets:

(7) a. $(ami)_{\text{PhP}}\ (b^{h}ut\ dek^{h}lam)_{\text{PhP}}$ = (6a)

b. $(ami)_{\text{PhP}}\ (b^{h}ut)_{\text{PhP}}\ (dek^{h}lam)_{\text{PhP}}$ = (6b)

Butt and King (1998) represent p-structure as a feature structure, similar to f-structure. The p-structure they propose for the idiomatic reading composed of two PhPs is given in (8), and the p-structure for the literal reading composed of three PhPs is given in (9). The p-structure feature DOM (prosodic DOMain) defines the level of constituent within the Prosodic Hierarchy that a particular feature structure represents, while the feature P-FORM represents a word's phonological form.

(8) *ami* b^{h}*ut* *dek*^{h}*-l-am.*
I ghost see-PST-1SG
'I was startled.' (idiomatic reading)

$$\left[\begin{array}{ll} \text{DOM} & \text{INTONATIONAL PHRASE} \\ & \left(\left\{\begin{array}{l} \left[\begin{array}{ll} \text{DOM} & \text{P-PHRASE} \\ & \left(\left\{ \left[\begin{array}{ll} \text{DOM} & \text{P-WORD} \\ \text{P-FORM} & \text{AMI} \end{array}\right] \right\}\right) \end{array}\right] \\ \\ \left[\begin{array}{ll} \text{DOM} & \text{P-PHRASE} \\ & \left(\left\{\begin{array}{l} \left[\begin{array}{ll} \text{DOM} & \text{P-WORD} \\ \text{P-FORM} & \text{B}^{\text{H}}\text{UT} \end{array}\right] \\ \\ \left[\begin{array}{ll} \text{DOM} & \text{P-WORD} \\ \text{P-FORM} & \text{DEK}^{\text{H}}\text{LAM} \end{array}\right] \end{array}\right\}\right) \end{array}\right] \end{array}\right\}\right) \end{array}\right]$$

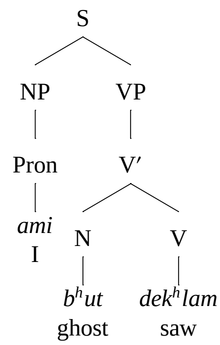
(9) *ami* b^{h}*ut* *dek*^{h}*-l-am.*
I ghost see-PST-1SG

'I saw a ghost.' (literal reading)

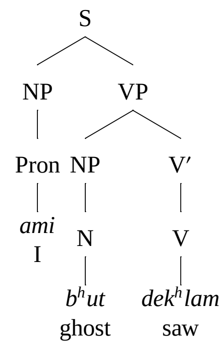
$$\left[\begin{array}{ll} \textsc{dom} & \textsc{intonational phrase} \\ & \left\{ \begin{array}{l} \left[\begin{array}{ll}\textsc{dom} & \textsc{p-phrase}\\ & \left\{\left[\begin{array}{ll}\textsc{dom} & \textsc{p-word}\\ \textsc{p-form} & \textsc{ami}\end{array}\right]\right\}\end{array}\right] \\ \\ \left[\begin{array}{ll}\textsc{dom} & \textsc{p-phrase}\\ & \left\{\left[\begin{array}{ll}\textsc{dom} & \textsc{p-word}\\ \textsc{p-form} & \textsc{b}^{\textsc{h}}\textsc{ut}\end{array}\right]\right\}\end{array}\right] \\ \\ \left[\begin{array}{ll}\textsc{dom} & \textsc{p-phrase}\\ & \left\{\left[\begin{array}{ll}\textsc{dom} & \textsc{p-word}\\ \textsc{p-form} & \textsc{dek}^{\textsc{h}}\textsc{lam}\end{array}\right]\right\}\end{array}\right] \end{array} \right\} \end{array}\right]$$

Butt and King (1998) propose that p-structure is projected from c-structure just as f-structure is, and that prosodic constituents such as IntPs and PhPs are derived from syntactic constituents by means of mapping processes. The relevant mapping processes permit not only isomorphism, but also some degree of difference between the two structures (for example, by increasing or decreasing the levels of embedding in p-structure relative to the c-structure input). With respect to the ambiguity of (6), Butt and King argue that the prosodic distinction between the two readings corresponds to a difference in c-structure. In the case of the idiomatic reading, Butt and King analyze the NP $b^{h}ut$ 'ghost' and the V $dek^{h}lam$ 'saw' as sisters at c-structure; together they constitute a V′, as shown in (10). This single bar-level syntactic constituent corresponds to a single PhP in the relevant prosodic representation (8). By contrast, in the literal reading the NP $b^{h}ut$ 'ghost' occupies specifier position in the VP, as shown in (11). The syntactic relationship between the NP and the verb is not as close as in the case of the idiomatic reading, and this is also the case in the prosodic representation (9): the two relevant syntactic constituents correspond to two separate PhPs rather than forming one PhP.

(10) *ami b*^{h}*ut dek*^{h}*-l-am.*
I ghost see-PST-1SG
'I was startled.'



(11) *ami b*^{h}*ut dek*^{h}*-l-am.*
I ghost see-PST-1SG
'I saw a ghost.'



Butt and King (1998) state that their feature-structure representation of p-structure is equivalent to a tree structure representation of the type shown in (5), but they acknowledge a deficiency in the representation: the feature structure's contents are unordered. They therefore find it necessary to rely on a notion of projection precedence, assuming that information about ordering is indirectly available from the c-structure, as for the f-precedence relation on f-structures (see Chapter 6, Section 11.4). Another issue with feature structures as a means of representing prosodic structure, highlighted by O'Connor (2006, pages 151–152), is that an enriched theory of phonological structure is required in order to associate text (i.e. the words in an utterance) with a tune (i.e. an intonational contour) because tonal information at the phrasal level cannot be directly associated with the relevant text in the feature-structure approach. In subsequent work, the original feature-structure approach of Butt and King (1998) has been rejected in favor of other means of representation.

On Butt and King's view, p-structure is fundamentally derivative of the c-structure, even though it is a distinct level of linguistic structure. While the overall approach is one of indirect reference, by conceiving of p-structure as a projection from c-structure Butt and King (1998) ultimately base their definitions of p-structure units on syntactic constituency. On this view, isomorphism is the default; when p-structure differs from c-structure, it is as a result of additional processes applying. As noted in Section 2.1, this assumption about the nature of the relationship between syntax and prosody has been challenged.

The next significant work on prosodic structure within LFG was on English and Bosnian/Croatian/Serbian by O'Connor (2005a,b, 2006) and by Mycock (2006) in the context of the typology of constituent question formation. They assume, with Butt and King (1998), that p-structure is a separate level within the parallel architecture, but both abandon the feature-structure representation in favor of tree structures. In this respect, O'Connor (2006) and Mycock (2006) share a good deal of common ground. They propose "tune structure" and "contour" rules respectively to capture facts about intonational contours that apply to specific prosodic domains. O'Connor adopts the Autosegmental-Metrical/Tones and Break Indices (AM/ToBI) framework for the expression of tune structure rules.[7] Mycock (in her PhD thesis and in later work) stops short of doing the same, but the p-structure rules with which she works are broadly compatible with an AM/ToBI approach. In terms of empirical focus, O'Connor (2006) and Mycock (2006) are both concerned with how prosody interfaces with other parts of the grammar. In particular, they seek to capture the important role that prosody can play in signaling information structure status. Mycock (2006) also analyzes scope marking in constituent questions with reference to p-structure, offering a way to model the prosody-semantics interface in LFG. Where these two approaches differ significantly is in the location of p-structure in the architecture. Mycock (2006) follows Butt and King (1998) in assuming that p-structure is projected from c-structure (and thus inherits the issues with such an approach discussed above), but augments this with the proposal that p-structure maps to s-structure (and i-structure) independently of syntax in order to account for the type of phenomena exemplified in (2), which show that prosody can make a crucial contribution to meaning. O'Connor (2006) takes a different view, according to which p-structure has a direct relationship only with a level which he refers to as discourse structure. The architecture which O'Connor proposes is non-standard and has not been adopted beyond his work; we do not consider it further here.

Perhaps surprisingly, given LFG's co-description architecture and the general commitment to modularity, the next major proposal concerning the analysis of prosody, put forward by Bögel et al. (2009), did not include a separate level of prosodic representation. As a result, this work has less in common with the indirect reference approaches outlined in Section 2.1 than the LFG analyses which preceded it. Bögel et al. (2009) proposed a "pipeline architecture" as a way of capturing facts about the (mis)alignment of prosodic and syntactic constituents. Rather than treating prosodic structure as projected from c-structure, Bögel et al. argue that prosodic information feeds into c-structure analysis. In their model, the input to c-structure is a prosodically bracketed string. Phrase structure rules then apply as normal to produce a valid c-structure for the string, but with one significant augmentation: phrase structure rules are formulated so as to make reference not only to syntactic categories but also to prosodic brackets. These rules are used in Bögel et al. (2009) to capture the misalignment which characterizes the syntax-prosody relation in Germanic languages that, as Lahiri and Plank (2010) discuss, is often due to the differing behavior of function words in the formation of syntactic and prosodic constituents. Lahiri and Plank exemplify using an old advertising slogan:

(12) a. Syntactic Phrasing: *[Drink [a [pint [of milk]]] [a day]]*

b. Prosodic Phrasing: *(Drink a) (pint of) (milk a) (day)*

[7] For an introduction to AM/ToBI see Beckman et al. (2005) and Ladd (2008); for ToBI analyses of data from a range of languages, see the papers in Jun (2005, 2014).

The bracketing in (12) shows that the English function words *a* and *of* group with a constituent to their right in the syntax, but to their left in the prosody. (In fact, the slogan appeared in writing as *Drinka pinta milka day*, reflecting the prosodic bracketing shown.) In their analysis of this example, Bögel et al. (2009) propose that the phonological string undergoes prosodic parsing, which introduces the relevant prosodic boundaries into the string. This "prosodically annotated string" is then the input to the syntactic component:

(13)	Phonological String	*Drink a pint a milk a day*
	Prosodic Parser	|
	Prosodically Bracketed	(Drink a) (pint a) (milk a) (day)
	Syntactic Parser	|
	Syntactic Analysis	[(Drink [a) [(pint [of) (milk]]] [a) (day)]]

A key feature of this pipeline architecture is that syntax can interpret the prosodic boundaries that are inserted into the string. Though this is not relevant for the example in (13), it is crucial to Bögel et al.'s (2009) account of the role of prosody in resolving syntactic ambiguity. For example, the phrase in (14) is ambiguous, depending on what exactly the AdjP *old* modifies, and is compatible with either of the syntactic analyses indicated.

(14) *old men and women*
 a. [[old men] and [women]]
 b. [old [men and women]]

The ambiguity is resolved when prosodic phrasing is available. (15a) is compatible with the syntactic analysis in (14a), while (15b) pairs with (14b). That is, the preference is for alignment of syntactic and prosodic boundaries:

(15) *old men and women*
 a. (old men) (and women) = (14a)
 b. (old) (men and women) = (14b)

Bögel et al. capture this fact about alignment with their Principle of Prosodic Preference: "syntactic structures with constituent boundaries that do not coincide with prosodic boundaries are dispreferred". While this approach successfully accounts for the role that prosody can play in resolving syntactic ambiguity and captures cases of mismatch between syntax and prosody, it does so at the cost of introducing prosodic information into the syntax macromodule. In an important respect, this violates the grammatical principle of modularity (Chapter 7, Section 2): the syntactic module should not be able to interpret non-syntactic objects. This is circumvented by proposing that a prosodic boundary has an additional role as one of two syntactic categories (left boundary, LB, or right boundary, RB), with the result that prosodic objects are effectively "disguised" as being syntactic: under this approach, LB and RB are terminal nodes in the c-structure tree. This does not represent a strictly modular approach to the issue. Moreover, the rather simplified prosodic representation involving LB and RB that Bögel et al. (2009) adopt does not allow easy reference to the different types of units that belong to the Prosodic Hierarchy, something which is essential in the analysis of many phenomena. Presumably, reference to distinct prosodic units could be made via a separate, additional prosodic component introducing a large number of differently labeled prosodic brackets into the string, but this adds further complexities. Bögel et al. (2009) do not explore the details or the wider implications of including such a component. Subsequent work on prosody and its interfaces within LFG has moved away from the "pipeline" architecture proposed by Bögel et al. (2009) and returned to an approach in which prosodic structure represents a distinct level in the parallel architecture, a position more compatible with strict modularity. In later work such as Bögel (2015), Bögel rejects the prosodic hierarchy as the basis for p-structure.

4. MODELING THE PROSODY-SYNTAX INTERFACE

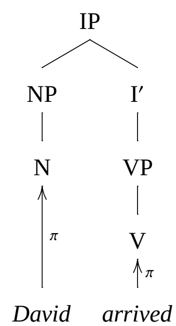
We now present the model of the prosody-syntax interface that we adopt in this book. Espousing a strong commitment to modular specificity and the indirect reference approach, Dalrymple and Mycock (2011) propose a new model for integrating prosody with the wider LFG grammar. This model conforms to three important criteria, addressing issues raised in the two previous sections. Firstly, it enables the contribution of prosody to different components of the grammar to be modeled with relative ease. Secondly, it does not assume any sort of close correspondence between the syntactic and prosodic phrase structures of an utterance, though it does permit any such correspondence to be accounted for. Thirdly, it respects the principle of modularity of the grammar, maintaining a strict separation between syntactic and prosodic information. In Dalrymple and Mycock's model, although prosody may contribute to syntax, semantics and information structure, no structure is able to interpret prosodic information except the prosodic component, and the prosodic component itself is unable to interpret anything but prosodic information.

Dalrymple and Mycock's (2011) model of the prosody-syntax interface was further developed and streamlined by Mycock and Lowe (2013). In the following sections, the model that we present is essentially the Mycock and Lowe version.

4.1. The P-String and the S-String

In Chapter 3, Section 5, we adopted the proposal of Kaplan (1987, 1995) that the string of words usually treated as constituting the terminal nodes of the c-structure tree should be thought of as a separate structure from the c-structure. Under this proposal, the string is related to the c-structure by a projection function, labeled π, from string elements to terminal c-structure nodes; terminal c-structure nodes are therefore not words, but X^0 or $\widehat{\mathrm{X}}$ level categories. This is illustrated below for the sentence *David arrived*.

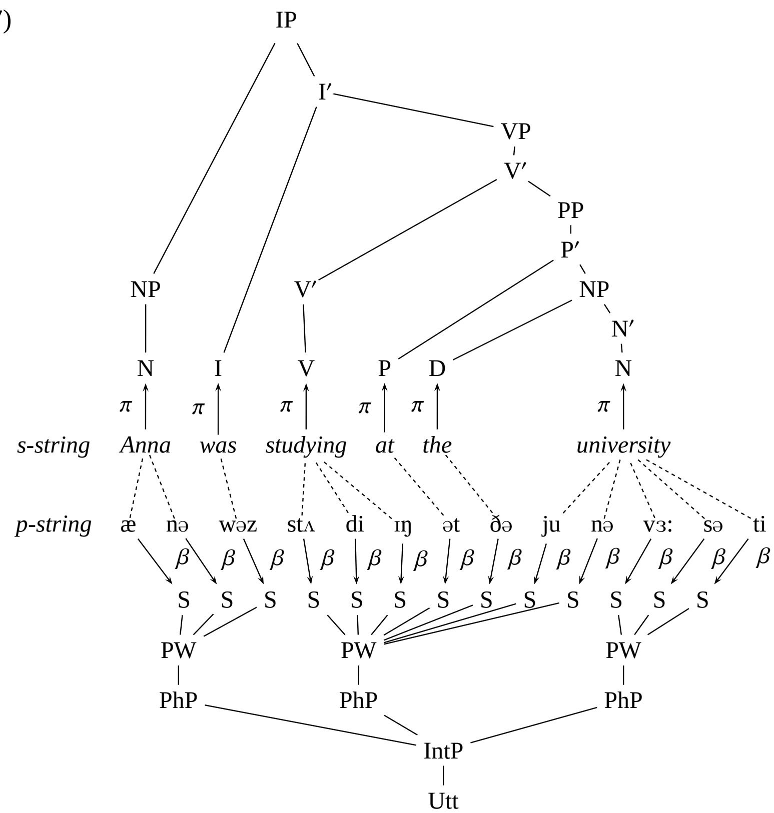
(16) David arrived.



The string can be thought of as a grammatical signal parsed into minimal units. The majority of analyses assume this view of the string: it is regarded as comprising minimal syntactic units which are then subject to phrase-structural analysis in the c-structure, via the π projection. However, this ignores the fact that a string can also be parsed into minimal phonological/prosodic units. The string, as Asudeh (2009, page 107) observes, thus represents part of the syntax-phonology interface.

Dalrymple and Mycock (2011) were the first to make a detailed proposal concerning this dual nature and function of the string. They argue that the string must be analyzed as having two distinct aspects: one syntactic, the *s-string*, the other phonological/prosodic, the *p-string*. Any linguistic signal can be parsed in two ways: the s-string represents the parsing of a signal into minimal syntactic units, and so corresponds to the conception of the string in most earlier works, while the p-string represents the parsing of a signal into minimal phonological/prosodic units. Just as the s-string is the basis of the syntactic phrase-structural analysis of an utterance, so the p-string is the basis of the prosodic phrase-structural analysis. To give an example, in Germanic languages units are formed according to the types of rhythmic principles highlighted by Lahiri and Plank (2010), along with the structure of the Prosodic Hierarchy; see Section 2 of this chapter. The units of p(rosodic)-structure are native to the phonology macromodule, and the projection of p-structure is based on phonological and prosodic features; there is no sense in which p-structure is derived from syntactic phrase structure, and no assumption of a necessarily close correlation between syntactic and prosodic phrase structure. The two are, of course, related to one another, but it is the string which represents the point of interface; thus, modularity is respected. Dalrymple and Mycock (2011) illustrate their proposals using the sentence *Anna was studying at the university*, providing a "double-tree" analysis of the two aspects of the string. The s-string, p-string, c-structure and p-structure which they propose — with some emendations to bring it in line with proposals by Mycock and Lowe (2013) — are shown in (17). The units of the s-string are each related to a terminal node of the c-structure via the π projection. The prosodic units related to these syntactic units form the p-string. Parallel to the syntactic analysis of this utterance, the units of the p-string are each related to a terminal node of the p-structure via the β projection, with "S" standing for syllable. Thus, the two aspects of the string receive equivalent but distinct analyses.[8]

(17)

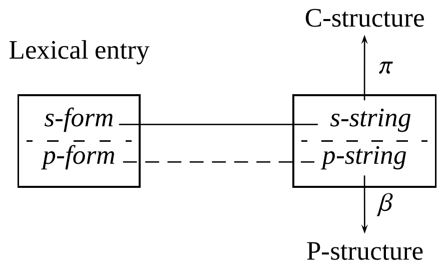


The relation between s-string and p-string units or, to put it another way, between the syntactic and prosodic parses of an utterance, is represented in (17) using dotted lines. Dalrymple and Mycock (2011) propose that the s-string–p-string relation is defined by information stored in lexical entries. Underpinning their proposal is a more fine-grained understanding of the nature and content of lexical entries, according to which a lexical entry specifies both a *s(yntactic)-form* and a *p(honological)-form*, as well as the c-structure category and f-description. The co-occurrence of s-forms and p-forms in lexical entries constrains the analysis of

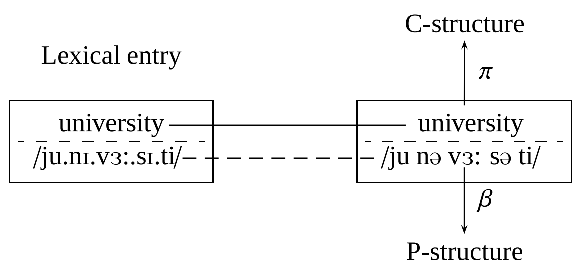
[8] In (17), each PW is also a separate PhP, but it could be the case that, for example, the PWs are grouped into two PhPs, giving (æ nə wəz stʌ di ɪŋ ət ðə ju nə)$_{\mathrm{PhP}}$ (vɜː sə ti)$_{\mathrm{PhP}}$. Our approach is flexible in order to account for the attested variability in intonation mentioned in Section 1. While for our purposes, nothing in (17) hinges on the placement of PhP boundaries, their inclusion is important because they can be associated with other aspects of prosody. For instance, voicing assimilation in Bengali is bounded within PhPs (Hayes and Lahiri 1991). Thus, even if a PhP comprises a single PW, this does not mean that the two can or should be conflated.

a string by requiring that any lexical item identified as a syntactic unit necessarily corresponds to a phonological/prosodic unit or units, in the same relative position in the string. The role of the lexical entry in mediating between the s-string and the p-string is illustrated in (18). The diagram in (19) exemplifies the portion of the grammatical architecture for the noun *university* which appears in (17).

(18)



(19) Lexical entry, s-string, and p-string: Dalrymple and Mycock (2011)



Dalrymple and Mycock (2011) therefore use the p-string, the s-string, and the lexicon to model the interface between the syntax and phonology macromodules.

Under this analysis, information of various kinds can be associated with s-string and p-string units. Mycock and Lowe (2013) develop Dalrymple and Mycock's (2011) approach to lexical entries by proposing that s-string and p-string units are not atomic, but in fact are bundles of information which they represent as feature structures.

A key component of any feature structure representing a unit of the s-string or p-string is the feature FM (FORM), whose value is related to the s-form or p-form of a lexical entry. For example, the lexical entry for *university* includes:

(20) (• FM) = university

The symbol • is used to refer to s-string units (Mycock and Lowe 2013). In the case of an s-string FM feature such as that shown in (20), the relation with the s-form in the relevant lexical entry (i.e. university) is one of identity. That is, the s-form of a word as it appears in a lexical entry is identical to the value of the FM feature in any s-string instantiation of that word. In the case of the p-string, on the other hand, this is not the case. For instance, the p-form of *university* includes five syllables (shown separated by periods), of which the second and fourth syllables contain the vowel /ɪ/: [9]

(21) /ju.nɪ.vɜː.sɪ.ti/

Notice that in the p-string in (17) the vowels in those same syllables are realized as /ə/. Phonological processes related to speech tempo and other contextual factors may apply, rendering the relation between p-forms and p-string FM features opaque. (It is important that the underlying vowels are retrievable though, as speakers can clearly access and produce them in instances of slow, careful production.) In informal terms it is not difficult to see how the application of such phonological processes affects the derivation of p-string FM features from p-forms, and likewise how the corresponding undoing of those same rules affects the reconstruction of p-forms from p-string FM features. For the present purposes, however, we make no proposals regarding the precise formalization of this aspect of phonology.[10]

The other respect in which FM features differ from the s-forms and p-forms of lexical entries is the possibility of many-to-one correspondences. Again, this is clearly seen by comparison of (21) with (17). The single p-form of the lexical entry in (21) corresponds to five distinct units in the p-string representation. Under a feature-structure approach, each of these p-string units is represented as a distinct p-string feature structure with its own p-string FM feature; that is, there is one p-string unit, represented as a separate feature structure, for each syllable. We assume that the specification of p-string units is part of the lexical information stored in lexical entries.[11]

Of course, FM features and their values are not the only components of a lexical entry. Each lexical entry also includes a c-structure category and f-description. At this point, we must note an inconsistency in the formal details of the presentation so far. Following long-established tradition in LFG, we have been using the variable ↑ in f-descriptions in lexical entries. Thus, for example, the f-structure number feature for *university* is specified by the f-description (↑ INDEX NUM)=SG. However, as discussed in Chapter 5, Section 3.1, the variable ↑ is an abbreviation for $\phi(\hat{*})$, that is, the f-structure projected, via the ϕ function, from the mother of the current c-structure node. This variable was appropriate when a syntactic element such as *university* was conceived of as a terminal node of the c-structure tree, with the preterminal node N as its mother. In that case, ↑ refers to the f-structure corresponding to the N node, as required. However, as discussed in Chapter 3, Section 5 and at the start of the current section, most major approaches to the LFG architecture follow Kaplan (1987, 1995) in understanding the (s-)string to

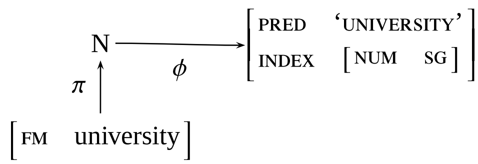
[9]This is a simplification. As Bögel (2015) observes, following Levelt et al. (1999), segments and the metrical frame are most likely stored separately in the lexicon. See Bögel (2015) for more on the precise contents of the p-form portion of a lexical entry.

[10]For a formalization of some postlexical phonological processes in an LFG setting, see Bögel (2015).

[11]This issue affects not only the p-form–p-string relation, but also the s-form–s-string relation, since single lexical entries can specify multiple s-string elements; see Lowe (2016a).

be distinct from the c-structure, related to it by the projection function π. Since $\uparrow$ is defined in terms of the mother function $\mathcal{M}$ on c-structure nodes, our use of $\uparrow$ in a lexical entry is therefore technically incorrect. What should rather be used is the distinct function $\phi(\pi(\bullet))$, which represents the f-structure projected, via the ϕ function, from the c-structure terminal node projected, via the π function, from the s-string unit with which the lexical entry is associated, as shown here:

(22)



The lexical entry for *university* (with its parts labeled) is therefore:[12]

(23)

s-form	$(\bullet\ \text{FM}) =$	university
c-structure category	$\lambda(\pi(\bullet)) =$	N
f-description	$(\phi(\pi(\bullet))\ \text{PRED}) =$	'university'
	$(\phi(\pi(\bullet))\ \text{INDEX NUM}) =$	SG
	university $\in$	$(\iota(\sigma(\phi(\pi(\bullet))))\ (\sigma(\phi(\pi(\bullet)))\ \text{DF}))$
p-form	/ju.nɪ.vɜː.sɪ.ti/	

While a lexical entry of this type is technically more accurate, the use of $\uparrow$ is a well-established tradition in LFG, and is certainly more readable. We therefore retain this traditional notation, on the understanding that $\uparrow$ appearing in a lexical entry refers to a different function from $\uparrow$ when it appears in phrase structure annotations. In a lexical entry, $\uparrow$ is defined as $\phi(\pi(\bullet))$, where the π function maps from units of the s-string to terminal nodes of the c-structure. In a phrase structure rule, $\uparrow$ is defined as $\phi(\hat{*})$ (or, to be completely explicit, as $\phi(\mathcal{M}(*))$, in terms of the mother function $\mathcal{M}$ on c-structure nodes).

4.2. Edge Features

Besides the FM feature, whose value is specified in each lexical entry, a range of other features can appear in string feature structures. Some of these are lexically specified; for example, a lexically stressed syllable is specified in the lexicon as having the feature SYLLSTRESS P. Other features represent properties that string elements may possess in a particular context. The most important of these contextually specified properties for our purposes is the association of string elements with information about the location of the beginning or end of syntactic or prosodic constituents. Reliance on such edge information is an acknowledged characteristic of prosody and its interaction with other aspects of linguistic structure, and as such has been integral to models of prosody and its interfaces over

[12] On the function λ, which relates a node of the tree to its label, see Chapter 5, Section 1.2.

the years, for instance the end-based (also known as the edge-based) approach of Selkirk (1986) and the ALIGN family of constraints in Optimality-Theoretic approaches including Selkirk (1995). Following Dalrymple and Mycock (2011), Mycock and Lowe (2013) assume that string units appearing in particular contexts are associated with sets of labels. These labels represent the left and right edges of the constituents in the associated structure that belongs to the relevant module of the grammar (i.e. c-structure or p-structure). So, in (17), the s-string element 'Anna' is associated with the left edge of the IP in the c-structure, and also with both the left and right edges of an NP and N. This is represented in the relevant string unit by means of features L (left edge) and R (right edge) whose values are sets comprising information concerning which constituents this particular s-string unit represents the left or right edge of. Thus, because the N *Anna* is the left edge of the IP, NP and N constituents and the right edge of the NP and N constituents, the representation of the s-string unit for *Anna* in (17) is:

(24) $\begin{bmatrix} \text{FM} & \text{Anna} \\ \text{L} & \{\ \text{IP, NP, N}\ \} \\ \text{R} & \{\ \text{NP, N}\ \} \end{bmatrix}$

There are two p-string elements corresponding to the s-string unit for *Anna*: 'æ' and 'nə'. The first of these is associated with the left edge of a PW, a PhP, the IntP and the Utt in the p-structure. As is the case for edge information related to s-string units, this edge information about p-string units appears as values of the features L and R within p-string attribute structures, as shown in (25).[13]

The features FM, L and R are not the only features that have been proposed for s-string and p-string attribute structures. Mycock and Lowe (2013) also include prosodic information associated with particular p-string units in p-string feature structures. For example, they assume the feature SYLLSTRESS with value P in order to represent the location of primary stress. Thus, the full representation of the two p-string units for *Anna* in (17) is:

(25) $\begin{bmatrix} \text{FM} & \text{æ} \\ \text{SYLLSTRESS} & \text{P} \\ \text{L} & \{\ \text{Utt, IntP, PhP, PW}\ \} \\ \text{R} & \{\ \ \} \end{bmatrix} \quad \begin{bmatrix} \text{FM} & \text{nə} \\ \text{L} & \{\ \ \} \\ \text{R} & \{\ \ \} \end{bmatrix}$

The mechanism by which c-structure and p-structure category edge information is specified as appearing in s-string and p-string features is defined by Mycock and Lowe (2013) in terms of the relation between a c-structure or p-structure node and its rightmost or leftmost daughter. They define a relation *D* which, when applied to a c-structure or p-structure node, finds the set of immediate daughter nodes of the node to which it applies; it is therefore the inverse of the mother relation $\mathcal{M}$ discussed in Chapter 5, Section 3.1. The leftmost immediate daughter

[13]For a different approach to capturing prosodic phrasing and its encoding in LFG, see Bögel's work on the p-diagram. Bögel (2015) provides full details; see also Section 7.

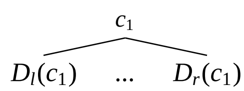
of the node in question can then be defined as the member of the set of daughter nodes which is not preceded, in linear terms, by any other member of the same set. Likewise, the rightmost immediate daughter of the node can be defined as the member of the set of daughter nodes which is not followed, in linear terms, by any other member of the same set. These functions, from nodes to leftmost and rightmost immediate daughters, are labeled D_l and D_r respectively, and are defined, in relation to c-structure nodes, as follows:

(26) a. $D_l(*) \equiv$ node n, where $n \in D(*) \wedge \neg\exists x.x \in D(*) \wedge x \prec n$.

b. $D_r(*) \equiv$ node n, where $n \in D(*) \wedge \neg\exists x.x \in D(*) \wedge x \succ n$.

This is shown graphically in (27), where the mother node is represented as c_1, the leftmost daughter is $D_l(c_1)$, and the rightmost daughter is $D_r(c_1)$:

(27)



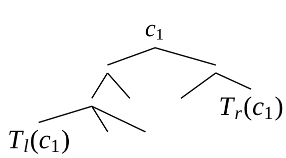
The leftmost and rightmost *terminal* nodes dominated by a node can be defined by the recursive application of these functions until a node is reached that has no daughters. Mycock and Lowe (2013) label the functions that find these terminal nodes as T_l and T_r respectively. The definitions they provide are given in (28). These rules can be informally read as follows: the leftmost/rightmost terminal node from the current node is the current node if the current node has no daughters; otherwise, it is the leftmost/rightmost terminal node of the leftmost/rightmost daughter (respectively) of the current node. The rule applies recursively to find the appropriate terminal descendant of any node.

(28) a. $T_l(*) \equiv \begin{cases} * & \text{if } D(*) = \emptyset \\ & \text{else } T_l(D_l(*)) \end{cases}$

b. $T_r(*) \equiv \begin{cases} * & \text{if } D(*) = \emptyset \\ & \text{else } T_r(D_r(*)) \end{cases}$

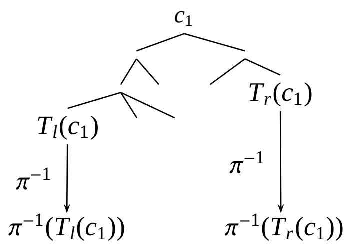
In (29) we display a sample tree in which the current node ($*$ in the definitions above) is represented as c_1, the leftmost terminal daughter is $T_l(c_1)$, and the rightmost terminal daughter is $T_r(c_1)$:

(29) Sample configuration: $T_l(c_1)$ is the leftmost terminal daughter of c_1, and $T_r(c_1)$ is the rightmost terminal daughter



Finally, the s-string elements corresponding to these terminal nodes are straightforwardly obtained by applying the inverse function π^{-1} from terminal nodes of the c-structure to elements of the s-string. In (30), the leftmost s-string element of the node labeled c_1 is $\pi^{-1}(T_l(c_1))$, and the rightmost s-string element is $\pi^{-1}(T_r(c_1))$.

(30) Sample configuration: $\pi^{-1}(T_l(c_1))$ is the leftmost s-string element of c_1, and $\pi^{-1}(T_r(c_1))$ is the rightmost s-string element



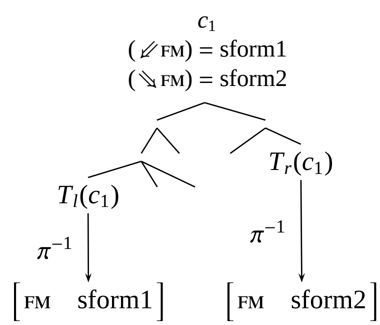
Mycock and Lowe (2013) propose to use arrows as abbreviations for the paths from c-structure nodes to leftmost and rightmost string elements. The arrow $\Swarrow$ abbreviates the function from a c-structure node to the leftmost s-string element dominated by it, and the arrow $\Searrow$ abbreviates the function from a c-structure node to the rightmost s-string element dominated by it:

(31) a. $\Swarrow \equiv \pi^{-1}(T_l(*))$

b. $\Searrow \equiv \pi^{-1}(T_r(*))$

The tree in (32) provides an example of the use of $\Swarrow$ and $\Searrow$:

(32) Example: $\Swarrow$ and $\Searrow$



In a parallel manner, the arrows $\swarrow$ and $\searrow$ abbreviate the functions from a p-structure node to its leftmost and rightmost p-string elements. The definitions for these arrows are given in (33), where $\diamond$ refers to any p-structure node (i.e. this is the equivalent of $*$ at c-structure). Recall that β is the mapping from elements of the p-string to terminal nodes of the p-structure; β^{-1} is the inverse function.

(33) a. $\swarrow \equiv \beta^{-1}(T_l(\diamond))$

b. $\searrow \equiv \beta^{-1}(T_r(\diamond))$

Use of the "syntax arrows" ⇙ and ⇘ and the "phonology/prosody arrows" ⤦ and ⤥ therefore permits direct reference from any c-structure or p-structure node to the s-string or p-string elements corresponding to the leftmost and rightmost terminal nodes which are descendants of the node in question. It is thus possible to express simple generalizations about the passing of category information to string elements, with annotation principles like those given in (34); these generalizations are encoded in all phrase structure rules in a language with phrase structure categories NP and N, and similar generalizations hold of other categories:

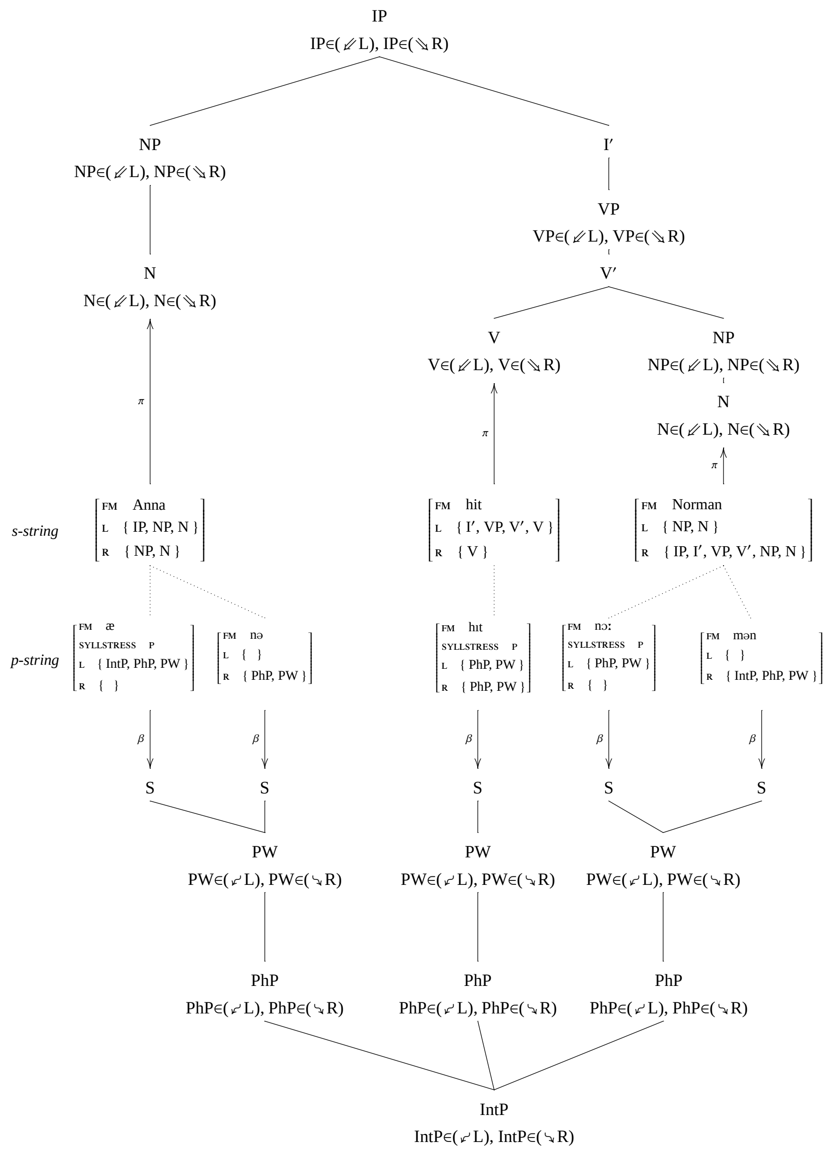
(34) a. For any NP, NP ∈ (⇙L) and NP ∈ (⇘R)

b. For any N, N ∈ (⇙L) and N ∈ (⇘R)

The tree in (35) explicitly shows these specifications on all c-structure and p-structure nodes. Notice that the labels appearing in the sets which are the values of each string unit's L and R features correspond exactly to the specifications made by the arrows in the c- and p-structures.

As mentioned previously, in addition to the features FM, L and R, Mycock and Lowe (2013) include prosodic information associated with particular p-string units in p-string feature structures and the feature SYLLSTRESS with value P, which appears in (35), represents the location of primary stress. Lowe (2016a) proposes a feature CLITIC, which can appear in both s-string and p-string units, to distinguish syntactic or prosodic clitics from non-clitics at the level of the string, and an s-string or p-string feature FIELD, which contains labels referring to all syntactic categories dominating a particular element in the c-structure or to all the prosodic categories dominating a particular element in the p-structure.

(35) *Anna hit Norman.*



The approach to prosody and its interfaces developed by Dalrymple and Mycock (2011) and illustrated in (35) makes crucial reference to edge information associated with string elements. Dalrymple and Mycock (2011) themselves note that “passing information about the edges of all major constituents into the p-string and s-string...may seem excessive”, but also point out that in at least some cases, for instance when speech is slower and more careful, a greater degree of alignment exists between syntactic and prosodic constituents, meaning that "information about constituent boundaries must be available at the interface in order that the relevant alignment principles can apply to give phrasing which reflects the appropriate degree of increased isomorphism". However, Dalrymple and Mycock also state that "this does not mean that we necessarily expect all of this information to emerge as being relevant at the interface. In fact, it is an important feature of this architecture that it enables us to explore the question of precisely which aspects of prosodic and syntactic structure are important at the interface and to investigate why this should be, both crosslinguistically and on a language-by-language basis".

One example of a case where alignment between syntactic and prosodic constituents is key is the type of disambiguation analyzed by Butt and King (1998) and presented in Section 3 of this chapter. To recap briefly, two readings are associated with the Bengali sentence in (36), with the ambiguity being resolved by prosodic phrasing:

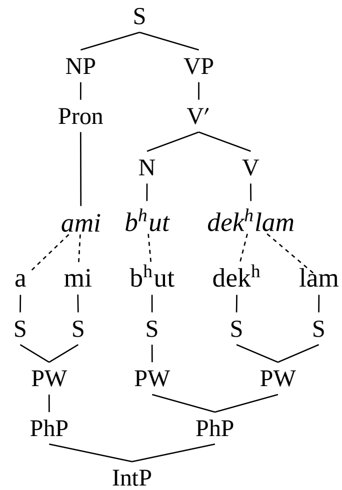
(36) *ami b^h^ut dek^h^-l-am.*
I ghost see-PST-1SG
Reading 1: (*ami*)$_{\text{PhP}}$ (*b^h^ut dek^h^lam*)$_{\text{PhP}}$ 'I was startled.'
Reading 2: (*ami*)$_{\text{PhP}}$ (*b^h^ut*)$_{\text{PhP}}$ (*dek^h^lam*)$_{\text{PhP}}$ 'I saw a ghost.'

Crucial to disambiguation of the sentence in (36) is the alignment of phrase-level p-structure and c-structure boundaries: the difference between Reading 1 and Reading 2 is whether *b^h^ut* ('ghost') is a phrase in its own right (i.e. a separate NP in the c-structure tree, and a separate PhP at prosodic structure). If *b^h^ut* is simultaneously the left *and* the right edge of a PhP in the p-structure, then it is also the left and right edge of a NP in the c-structure and the appropriate reading is Reading 2; otherwise, it is Reading 1.

In Dalrymple and Mycock's model (see also Mycock and Lowe 2013), a principle of "Interface Harmony" is important to the analysis of this and other instances of prosodic disambiguation, as well as to the increasing alignment which occurs as speech rate decreases. Interface Harmony requires that certain information introduced at c-structure (such as the location of a phrase's left or right edge, for example), which has its presence recorded via a label in the s-string (by virtue of being a member of the L or R set in such a unit's feature structure), must be matched with a label in the corresponding p-string unit; both labels should be values of the same feature (i.e. L or R) in the relevant string units. That is, at the interface between s-string and p-string, a principle of Interface Harmony applies which can require that two labels co-occur — one in an s-string unit and one in a p-string unit. Note that these are *labels*: they are associated with but do not in themselves constitute specific syntactic or prosodic information; they are not independent. Prosodic disambiguation relies on the alignment of c-structure and p-structure boundaries and therefore can be understood in terms of Interface Harmony. The Bengali example provided by Butt and King (1998) illustrates this well. In (37) we see how the boundaries of phrase-level prosodic constituents (parentheses) and syntactic constituents (square brackets) align in the respective readings.

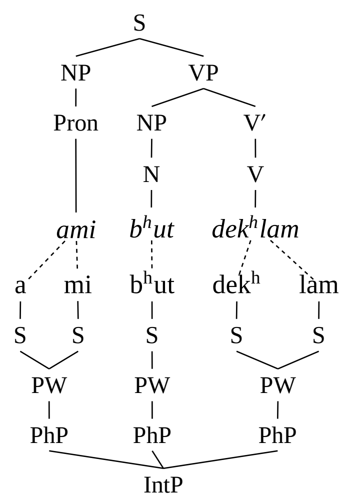
(37) a. Reading 1: ‘I was startled.’

[(*ami*)$_{\text{PhP}}$]$_{\text{NP}}$ [(*b^{h}ut dek^{h}lam*)$_{\text{PhP}}$]$_{\text{VP}}$



b. Reading 2: ‘I saw a ghost.’

[(*ami*)$_{\text{PhP}}$]$_{\text{NP}}$ [[(*b^{h}ut*)$_{\text{PhP}}$]$_{\text{NP}}$ (*dek^{h}lam*)$_{\text{PhP}}$]$_{\text{VP}}$



Each phrasal boundary in the syntax (NP or VP) has a corresponding PhP boundary in the prosodic analysis.[14] (There is no “double marking” or “double edge effect” if an edge of the VP also represents an edge of an NP.) The two readings are therefore associated with distinct c-structure and p-structure pairs. As proposed by Dalrymple and Mycock (2011), information about the edges of all major constituents is recorded as labels in L or R feature-value sets, by means of

[14]These boundaries are crucial in accounting for different voicing assimilation possibilities in these two examples; see Hayes and Lahiri (1991).

requirements like those given in (34). The string representations for the Bengali utterances, based on the analysis presented by Butt and King (1998) (which itself is based on that of Hayes and Lahiri 1991), are as shown in (38) and (39). Under neutral focus, a High tone, represented in the p-string feature structure as TONE H, is associated with the leftmost PW of the rightmost PhP in Bengali (Hayes and Lahiri 1991). This serves as an indicator of prosodic constituency, as the examples below show. The labels that align and upon which the disambiguation relies are given in bold in both examples; the first word *ami* 'I' is omitted.

(38) Reading 1: 'I was startled.'

s-string
$$\begin{bmatrix} \text{FM} & \text{b}^{\text{h}}\text{ut} \\ \text{L} & \{\, \mathbf{VP}, \text{V}', \text{N} \,\} \\ \text{R} & \{\, \text{N} \,\} \end{bmatrix} \qquad \begin{bmatrix} \text{FM} & \text{dek}^{\text{h}}\text{lam} \\ \text{L} & \{\, \text{V} \,\} \\ \text{R} & \{\, \text{S}, \mathbf{VP}, \text{V}', \text{V} \,\} \end{bmatrix}$$

p-string
$$\begin{bmatrix} \text{FM} & \text{b}^{\text{h}}\text{ut} \\ \text{SYLLSTRESS} & \text{P} \\ \text{TONE} & \text{H} \\ \text{L} & \{\, \mathbf{PhP}, \text{PW} \,\} \\ \text{R} & \{\, \text{PW} \,\} \end{bmatrix} \qquad \begin{bmatrix} \text{FM} & \text{dek}^{\text{h}} \\ \text{SYLLSTRESS} & \text{P} \\ \text{L} & \{\, \text{PW} \,\} \\ \text{R} & \{\ \} \end{bmatrix} \qquad \begin{bmatrix} \text{FM} & \text{lam} \\ \text{L} & \{\ \} \\ \text{R} & \{\, \text{IntP}, \mathbf{PhP}, \text{PW} \,\} \end{bmatrix}$$

(39) Reading 2: 'I saw a ghost.'

s-string
$$\begin{bmatrix} \text{FM} & \text{b}^{\text{h}}\text{ut} \\ \text{L} & \{\, \text{VP}, \mathbf{NP}, \text{N} \,\} \\ \text{R} & \{\, \mathbf{NP}, \text{N} \,\} \end{bmatrix} \qquad \begin{bmatrix} \text{FM} & \text{dek}^{\text{h}}\text{lam} \\ \text{L} & \{\, \text{V}', \text{V} \,\} \\ \text{R} & \{\, \text{S}, \text{VP}, \text{V}', \text{V} \,\} \end{bmatrix}$$

p-string
$$\begin{bmatrix} \text{FM} & \text{b}^{\text{h}}\text{ut} \\ \text{SYLLSTRESS} & \text{P} \\ \text{L} & \{\, \mathbf{PhP}, \text{PW} \,\} \\ \text{R} & \{\, \mathbf{PhP}, \text{PW} \,\} \end{bmatrix} \qquad \begin{bmatrix} \text{FM} & \text{dek}^{\text{h}} \\ \text{SYLLSTRESS} & \text{P} \\ \text{TONE} & \text{H} \\ \text{L} & \{\, \mathbf{PhP}, \text{PW} \,\} \\ \text{R} & \{\ \} \end{bmatrix} \qquad \begin{bmatrix} \text{FM} & \text{lam} \\ \text{L} & \{\ \} \\ \text{R} & \{\, \text{IntP}, \mathbf{PhP}, \text{PW} \,\} \end{bmatrix}$$

In the examples above, the principle of Interface Harmony, coupled with the rules of alignment in Bengali, mean that XP labels in an s-string feature structure are matched with phrase labels in the values of the L or R attributes of the corresponding p-string feature structure. This means that, ordinarily at least, the s-string in (38) is not paired with the p-string in (39), for example. Such constraints on wellformedness at the interface between the syntax and phonology macromodules, situated in the string, account for the relationship between c-structure and p-structure in cases of prosodic disambiguation, and for the ambiguity that remains when only the written form of the sentence is available because without p-structure constituent edges to match with, in principle either of the two c-string/s-string analyses is possible.

When it comes to Interface Harmony, determining exactly what prosodic information (for example, boundary type) is important to the syntax, and vice versa, is a key area for future research. For instance, in the Bengali examples we see that each NP forms a separate PhP comprising the relevant PWs, with the attendant result that in the literal reading (Reading 2), the V *dek^{h}lam* forms a PhP on its own. However, as we will see in the following sections, information about the location of syntactic and prosodic constituent boundaries is not the only sort of information that may be associated with string units and may therefore appear as values of the L and R features; importantly, any grammatical or prosodic feature may contribute a label to the feature structure of the s-string or p-string unit at its left or right edge. In the next two sections, we show how this approach to p-structure can be used to analyze phenomena in which prosody plays an important role.

5. DECLARATIVE QUESTIONS

The first phenomenon which we will explore with respect to prosody and its interfaces is that of English declarative questions. Similar to the Japanese example at the start of this chapter, in declarative questions prosody makes a crucial and unique contribution to the semantic and pragmatic interpretation of the utterance. Specifically, the intonational contour (or tune) is the only means by which a declarative question is marked as a type of question with interrogative semantics, rather than simply an ordinary declarative statement.[15] The relevant tune is characterized by a L(ow) tone preceding a final H(igh) tone; each tone is associated with a particular syllable, as shown:

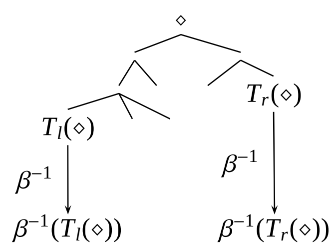
(40) Declarative question: declarative syntax, final rise in intonation
Anna was studying at the university?
ˈæ.nə.wəz.ˈstʌ.di.ɪŋ.ət.ðə.ju.nə.ˈvɜː.sə.ti
L H

Following a considerable body of work on intonational phonology (for an overview, see Ladd 2008), we assume that a tune such as the one associated with interrogative semantics in (40) minimally consists of a nuclear tone and a boundary tone. The nuclear tone is the pitch target which bears the main stress in an IntP. Boundary tones appear at one edge or both edges of an IntP. A left boundary tone is associated with the first syllable in an IntP, while a right boundary tone is associated with the final syllable in an IntP.

[15] In what follows, we assume that a declarative question has the same interpretation as an equivalent polar interrogative that is syntactically marked as such by subject-auxiliary inversion, for example *Was Anna studying at the university?* This is a simplification, as declarative questions exhibit contextual restrictions which polar interrogatives do not; on this, see, for example, Gunlogson (2003). Our aim here is to illustrate the mechanism whereby prosody can have an effect on meaning within the LFG framework. The full details of an LFG analysis of declarative questions await further research.

The English interrogative tune in (40) can be characterized as consisting of a L nuclear tone and a H right boundary tone. In the English interrogative tune, the nuclear tone is associated with the stressed syllable of the first PW in the last PhP in the IntP; see, for example, Hayes and Lahiri (1991). A tone is rendered simultaneously with the associated syllable. In order to model this, we must refer to the rightmost and leftmost p-string units in a prosodic projection *that are marked for primary stress*, that is the leftmost and rightmost syllables within a projection that are specified as being the location of primary stress (represented as the p-string feature SYLLSTRESS P). Recall that $T_l(\diamond)$ is defined as $\beta^{-1}(T_l(\diamond))$, the leftmost p-string element of the prosodic structure node $\diamond$; similarly, $T_r(\diamond)$ is defined as $\beta^{-1}(T_r(\diamond))$, the rightmost p-string element. β is the function from p-string elements to terminal nodes of the prosodic structure, and β^{-1} is the inverse of β. An example configuration is:

(41) $\beta^{-1}(T_l(\diamond))$ is the leftmost p-string element of the prosodic constituent $\diamond$, and $\beta^{-1}(T_r(\diamond))$ is the rightmost s-string element



Thus, we define the relations T_{ls} and T_{rs}, which pick out the stressed syllable closest to the left and right edge of a constituent $\diamond$, as follows:[16]

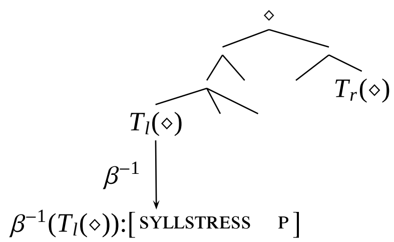
(42) a. $T_{ls}(\diamond) \equiv \begin{cases} T_l(\diamond) & \text{if } (\beta^{-1}(T_l(\diamond)) \text{ SYLLSTRESS}) =_c \text{P} \\ & \text{else } T_{ls}(\beta(N(\beta^{-1}(T_l(\diamond))))) \end{cases}$

b. $T_{rs}(\diamond) \equiv \begin{cases} T_r(\diamond) & \text{if } (\beta^{-1}(T_r(\diamond)) \text{ SYLLSTRESS}) =_c \text{P} \\ & \text{else } T_{rs}(\beta(N^{-1}(\beta^{-1}(T_r(\diamond))))) \end{cases}$

According to the first line of this definition, $T_{ls}(\diamond)$ is the leftmost syllable $T_l(\diamond)$ in the prosodic phrase if the p-string element corresponding to $T_l(\diamond)$ contains the feature SYLLSTRESS with value P. A sample configuration meeting these requirements is given in (43):

[16]The function N, which appears in (42), finds the next element in linear order when applied to string elements, as discussed in Chapter 6, Section 11.2; N^{-1} finds the preceding element.

(43) $(\beta^{-1}(T_l(\diamond))$ SYLLSTRESS$) = $ P



The second line of the definition of T_{ls} applies in case the leftmost syllable does not correspond to a stressed element of the p-string. In that case, we check the next p-string element to the right, and continue rightwards until we encounter a p-string element containing the feature SYLLSTRESS with value P.

As usual, we can introduce a convenient abbreviation for these concepts, using arrows superscripted with *s*:

(44) a. $\swarrow^{s} \equiv \beta^{-1}(T_{ls}(\diamond))$
b. $\searrow^{s} \equiv \beta^{-1}(T_{rs}(\diamond))$

In sum, the definitions of the functions $\swarrow^{s}$ and $\searrow^{s}$ are similar to the definitions of $\swarrow$ and $\searrow$ in (33). The only difference is the presence of an additional specification: these functions do not necessarily find the absolute leftmost and rightmost syllables, but rather the leftmost and rightmost syllables that have the feature-value pair which we use to represent primary stress, i.e. SYLLSTRESS P. These two pairs of arrows are all that we require to analyze declarative questions and prosodic focus marking, which is the subject of Section 6.

For the prosodic part of the analysis of a declarative question, the interrogative tune is a property associated with an IntP. The specification of this tune is introduced by a prosodic phrase structure rule, parallel to the syntactic phrase structure rules with which we are familiar.

(45) IntP $\longrightarrow$ PhP* PhP
$((\swarrow^{s}$ N_TONE$) = $ L$)$
$(\searrow$ RB_TONE$) = $ H

Line 1 of the annotation below the final PhP in (45) means that the value of N_TONE is L for the leftmost stressed syllable (i.e. the leftmost p-string unit including the feature-value pair SYLLSTRESS P) in this PhP. Line 2 requires the value of the rightmost p-string unit in this PhP to have an RB_TONE (right boundary tone) feature whose value is H. (45) captures the intonational contour we are concerned with, but what it does not do is link it to the semantic contribution associated with this interrogative tune. To capture this, we must turn now to the syntactic part of the analysis.

As discussed in Chapter 8, s(emantic)-structure is projected from f-structure, that is, from the syntax. As a consequence, it is necessary to associate the meaning constructor for interrogative semantics with a syntactic unit representing the clause as a whole. We assume a constructional meaning, introduced in the IP phrase structure rule, which contributes the relevant meaning constructor (Chapter 8, Section 6). For present purposes, we define the semantics of polar interrogativity as follows (which represents a simplification, but suffices for the purposes of illustration in this case):

(46) Polar interrogative meaning constructor:

$$\lambda P.Ques(P) : \uparrow_\sigma \multimap \uparrow_\sigma$$

We abbreviate this meaning constructor as **[PolarInt]**. This interrogative meaning contribution is associated with the right edge of the root node, IP. The phrase structure rule for English declarative questions is therefore:

(47) IP ⟶ XP I′
$\uparrow = \downarrow$
PolarIntSem ∈ (⇘ R)
[PolarInt]

This rule ensures that a label, "PolarIntSem", appears as a member of the set value of R in the rightmost s-string unit corresponding to the root IP. This specification always appears together with the polar interrogative meaning constructor **[PolarInt]**, as illustrated in (52) below.

Returning now to the prosodic part of our analysis, just as on the syntactic side, the interrogative tune specification is always accompanied by a further specification which defines a label *PolarInt*. This label appears as a member of the set value of R in the rightmost p-string unit in the IntP:[17]

(48) *PolarInt* ∈ (⤥ R)

Putting together (48) and (45), we have a specification of the interrogative tune which combines its tonal features with a label relating to polar interrogativity:[18]

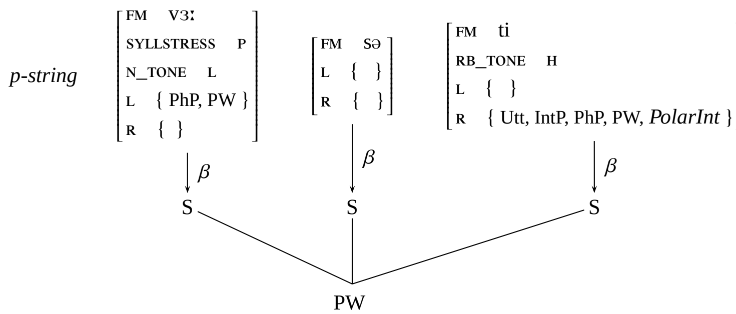
(49) IntP ⟶ PhP* PhP
(($\swarrow^{s}$ N_TONE) = L)
(⤥ RB_TONE) = H
PolarInt ∈ (⤥ R)

Following the analysis of Lahiri and Plank (2010), adopted here, the last three syllables of *university* form a prosodic word (PW). A partial representation of the p-structure and p-string for these three syllables illustrates the way this rule determines certain feature values:

[17] We follow Mycock and Lowe (2013) in distinguishing syntactic labels like "PolarIntSem" from prosodic labels like *PolarInt* by putting the latter in italics. Note that these are simply labels, and do not imply the presence of semantic properties in either the c-structure or p-structure: *PolarInt* could equally well be labeled *XYZ*, or "PolarIntSem" could be "XYZ".

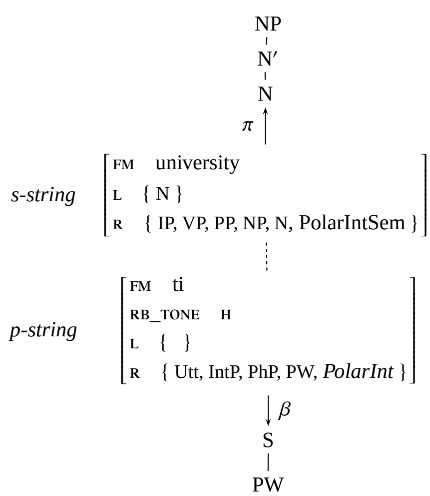
[18] Note that we do not assume a one-to-one relationship between a tune and meaning.

(50)



We are now in a position to put together the syntactic and prosodic aspects of our analysis of declarative questions. Crucial to this analysis are the feature values in the rightmost string feature structures, specifically “PolarIntSem” in the final s-string unit (see 47) and *PolarInt* in the final p-string unit (see 49), which are shown in this partial representation:

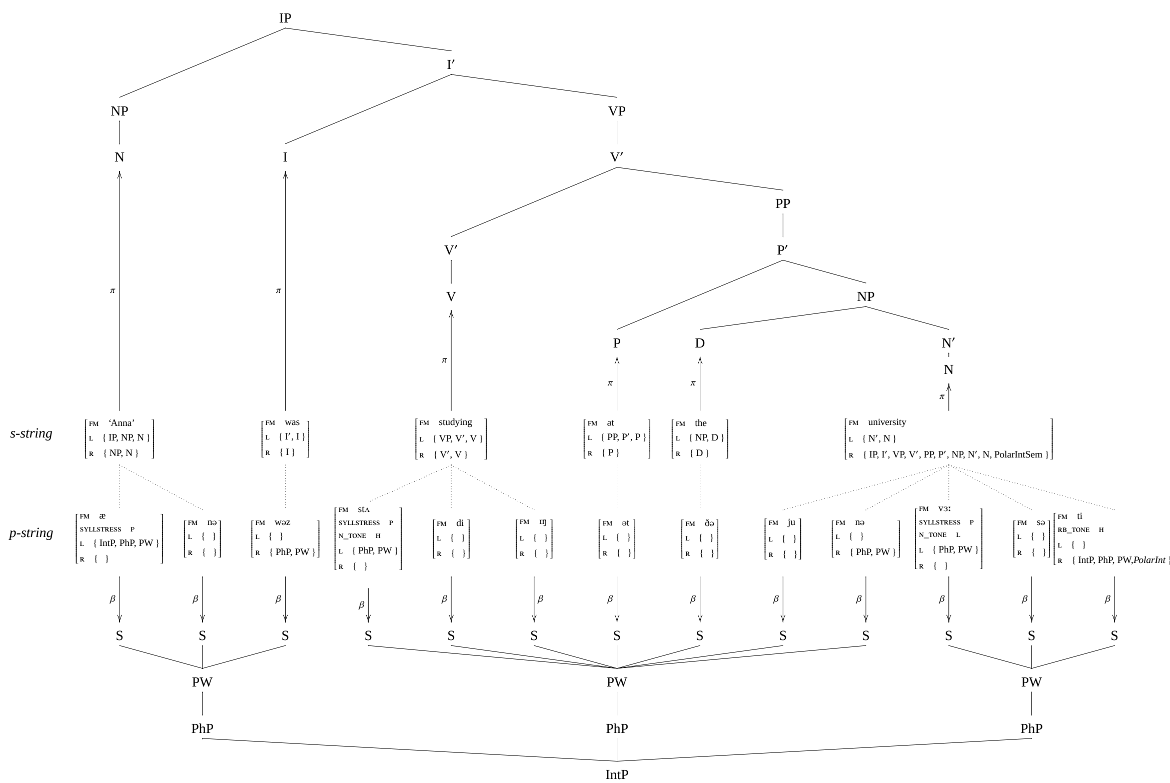
(51)



But what is the connection between the labels “PolarIntSem” and *PolarInt*? Both are clearly intended to link with polar interrogativity, which is characteristic of this construction, but the labels and the syntactic/prosodic structures with which they are associated are not directly dependent on one another: neither is derived from the other and their sphere of application is entirely separate, in line with strict modularity. And yet it is clear that the two must be related if the analysis is to achieve its aim of pairing the interrogative tune with the appropriate meaning constructor. Once again, the key assumption is the principle of Interface Harmony.

Interface Harmony requires that information about a meaning constructor introduced at c-structure (for example **[PolarInt]**), which has its presence recorded via a label in the s-string (i.e. "PolarIntSem"), must be matched with an equivalent label in the corresponding p-string unit (i.e. *PolarInt*). As in other cases, both labels should be associated with the same feature (i.e. L or R) in the relevant string units. Because the labels "PolarIntSem" and *PolarInt* are intrinsically related to one of the two separate phrase structure rules which introduce either the relevant meaning constructor or the relevant tune, the appropriate semantics and intonational contour must also co-occur. In the case of a declarative question, then, the principle of Interface Harmony applies so that, if "PolarIntSem" appears as a member of the set value of R in any s-string unit, then the equivalent label *PolarInt* must appear in the corresponding p-string unit as a member of the set value of R (along with the feature values associated with the rest of the interrogative tune phrase structure rule, as shown in 49 and 50). In the case of (52), the relevant labels co-occur and correspond to one another; if they did not, Interface Harmony would be violated and the resulting structures would be ungrammatical. The phrases to which these labels are related (IP on the syntactic side, IntP on the prosodic side) are also wellformed according to (47) and (49). This means that the structure shown in (52) is grammatical. In this way the contribution of prosody to syntax and semantics can be modeled in a framework that does not require a direct relation between syntactic and prosodic structure, and does not blur the distinction between these two modules of grammar.

(52)


IP
I′
NP
VP
N
I
V′
PP
V′
P′
V
NP
P
D
N′
N
s-string
p-string
FM 'Anna'
FM was
FM studying
FM at
FM the
FM university
S
PW
PhP
IntP

In this section, we have seen how to model p-structure and account for the ways in which it interacts with syntax and semantics. In the next section, we turn to another aspect of interpretation that can have a close relationship with prosody: information structure.

6. PROSODIC FOCUS MARKING

In this section, we explore how prosody can contribute to the interpretation of an utterance as a result of its relationship to information structure. In the following, we analyze data first discussed by Mycock and Lowe (2013); we broadly follow the proposals of Lowe and Mycock (2014), but alter their account slightly in order to maintain consistency with the model of information structure described in Chapter 10.

In the following English examples, the focused element can be identified as the element which bears the main or nuclear stress in the utterance (see, for instance, Ladd 2008). We identify this element as bearing the Nuclear Tone. The Nuclear Tone is the final pitch accent within the relevant IntP domain. This pitch accent is perceived as being the most prominent within the intonational contour under consideration. In a declarative statement such as the answer in (53), the Nuclear Tone is a H(igh) tone.

(53) Q: *Who did Anna hit?*
A: *Anna hit [**Norman**]$_{\text{FOCUS}}$.*
H

In this example, *Norman* in the answer corresponds to the queried constituent in the question, and thus functions as the focus in the reply sentence. Contrast this with the following example, where *Anna* corresponds to the questioned constituent, and hence is the focus. In this case, *Anna* bears the Nuclear Tone.

(54) Prosodic focus marking
Q: *Who hit Norman?*
A: *[**Anna**]$_{\text{FOCUS}}$ hit Norman.*
H

The answer sentences in (53) and (54) exemplify *narrow focus*: the word that bears prosodic focus marking is also the only element that bears focus status at information structure. However, it is also possible for a single word to bear prosodic focus marking when more than one word has focus status at information structure. This is known as *broad focus*, and is exemplified in (55). In (55a), the whole VP in the answer sentence has focus status, but the Nuclear Tone is associated with *Norman* (specifically, with the initial stressed syllable of *Norman*).[19] In (55b), the subject NP *some old woman* is the focus of the answer

[19]Here, we set aside the issue of an event, but not the type of that event, being presupposed in the context of *What happened?* or *What did X do (to Y)?* type questions. When such a question is asked,

sentence, but the Nuclear Tone is associated with the initial stressed syllable of *woman*; cf. (54).

(55) a. Q: *What did Anna do?*
A: *Anna [hit **Norman**]*$_{\text{FOCUS}}$.
H

b. Q: *Who hit Norman?*
A: *[Some old **woman**]*$_{\text{FOCUS}}$ *hit Norman.*
H

Although the distinction between broad and narrow focus is generally accepted in the literature on focus marking, in an important sense the analysis that we adopt here transcends the distinction between broad and narrow focus. This distinction depends on different correlations between focus in the syntax and information structure on the one hand, and the prosodic marking of focus status on the other. In the modular grammatical architecture which we assume, these different aspects of focus and its encoding are specified separately. Important to understanding these inextricably linked dimensions of the notion "focus" are two concepts which we refer to as *Extent of Focus* (Foc-Extent) and *Exponent of Focus* (Foc-Exponent). Foc-Extent (also known as the Focus Domain) refers to the portion of a sentence which can be said to have focus status in information structure terms, while Foc-Exponent is the indication at some level of representation, for example prosody (p-structure), of the focus status of part or all of a sentence.[20] In the examples in (55), square brackets enclose the syntactic elements that constitute the Foc-Extent, while the H Nuclear Tone annotation indicates the word (given in bold) which bears the focus marking (the main stress in the sentence).

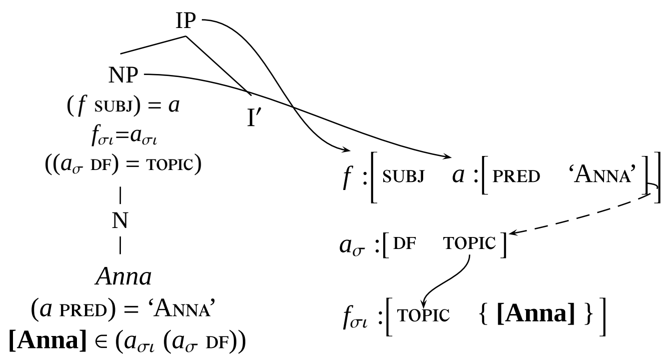
The Foc-Extent is the portion of a sentence which can be said to have Focus status. Of course, the precise definition of Foc-Extent depends on the general approach taken to information structure and its relation to other aspects of linguistic structure within the grammar. We define the Foc-Extent as the set of meaning constructors corresponding to syntactic elements that are associated with focus. In the approach introduced in Chapter 10, elements of a sentence's meaning — i.e. meaning constructors, which appear in bold in (56) — are categorized according to their discourse function (DF) at s(emantic)-structure, and consequently belong to the relevant set (for example TOPIC, FOCUS) at the level of i(nformation)-structure.

it is in fact only the type of the event that is in focus: the occurrence of some event is presupposed. On this, see Mycock (2006). For the purpose of illustrating the analysis of prosodic focus marking in LFG, we make the simplifying assumption that a single meaning constructor is associated with a verb, and thus that the verb is associated with a single discourse function at information structure. If one were to adopt a neo-Davidsonian approach to verb meaning instead, the distinction between event and event type could be captured using the s-structure attributes REL and EVENT (see Chapter 9, Section 10.5.2), and these two aspects of verb meaning could be analyzed as belonging to different information structure categories.

[20] Of course, information structure may also be indicated at other levels of structure, for example c-structure, but our concern here is with prosodic marking.

In (56), *Anna* is the subject of a clause, and is also the topic at i-structure by virtue of appearing in the specifier of IP. Key to this analysis is the attribute-value pair DF TOPIC included in the s-structure for 'Anna', a_σ. This information, combined with the annotations on the terminal node and the specifier of IP node in the c-structure, serves to categorize the relevant meaning constructor as belonging to the TOPIC set in the clause's i-structure, $f_{\sigma\iota}$.

(56)



Given the approach to i-structure exemplified in (56), Foc-Extent is equivalent to the set of meaning constructors which are the value of the attribute FOCUS at i-structure. These meaning constructors are semantic units and thus correspond — sometimes imperfectly — to units at other levels of representation, such as syntactic constituents.

It is possible to provide a relatively straightforward informal generalization concerning the relationship between Foc-Extent and Foc-Exponent in English: the Foc-Exponent is associated with the Prosodic Word which corresponds to the rightmost syntactic word that is the syntactic realization of the Foc-Extent. However, a full formal analysis represents a significant challenge, in large part because of the extensive misalignment that is a feature of the correspondences between units belonging to different levels of representation.

When we consider Foc-Exponent and Foc-Extent separately, the difference between narrow and broad focus collapses to an extent. Based purely on their syntax, these two types of focus are fundamentally the same: in all of the examples in (53), (54) and (55), the Foc-Extent is a single syntactic constituent. Similarly, the basic facts about the Foc-Exponent are the same in all cases: the rightmost Prosodic Word of the focus constituent bears the Nuclear Tone.

In order to provide an analysis of prosodic focus marking, we employ the mechanisms introduced previously, including the arrows defined in Section 4.1.

As with declarative questions, we represent the prosodic contour of a phrase with focus marking by means of prosodic phrase structure rules. Focus marking of the kind under discussion involves sentences that are declarative statements. We assume this prosodic phrase structure rule for declarative statements:[21]

[21] For the use of the ampersand here, see Chapter 6, Section 1.1.

(57) IntP → [PhP* PhP PhP*]
$(\searrow^{s}\ \textsc{n\_tone}) = \textsc{h}$

& [PhP* PhP]
$(\searrow\ \textsc{rb\_tone}) = \textsc{l}$

In addition to this, we require another rule to capture the focus-specific elements of the prosody of such clauses. It is possible to formulate a single p-structure rule (58) to account for nearly all the types of intonational focus marking in which we are interested. This rule states that any Prosodic Word (PW) in a Phonological Phrase may be marked for $\textsc{n\_tone} = \textsc{h}$, and if so, the label *DFFoc* appears as a member of the $\textsc{r}$ value of the corresponding p-string element that carries the Nuclear Tone.[22] The p-string element in which this feature appears is, specifically, the rightmost syllable that bears primary stress ($\searrow^{s}$) in the relevant PW.[23]

(58) PhP → PW* PW PW*
$(\searrow^{s}\ \textsc{n\_tone}) = \textsc{h} \Rightarrow$
$\mathit{DFFoc} \in (\searrow^{s}\ \textsc{r})$

The Foc-Exponent, captured by the rule in (58), serves to delimit the Foc-Extent. Foc-Extent is expressed via separate c-structure rules which, together with the p-structure rule in (58) and the principle of Interface Harmony, play an equally important role in the analysis of prosodic focus marking as an interface phenomenon.

In the case of the sentence in (53), the focus constituent in the answer sentence (*Norman*) could be identified with either the NP, the N′, or the N which dominates the word *Norman* in the c-structure. Following Mycock and Lowe (2013), we assume here that the phrase in question is the NP, since focused constituents often correspond to XP categories, but it makes no difference to the analysis of the present example.

We propose the following node annotation principle for Extent of Focus in English:

(59) Any c-structure node may optionally be annotated with the following two specifications:
DFFoc $\in (\Swarrow \textsc{l})$
DFFoc $\in (\Searrow \textsc{r})$

These constraints specify that the label "DFFoc" appears as a member of the set value of the features $\textsc{l}$ in the leftmost string element ($\Swarrow \textsc{l}$) and $\textsc{r}$ in the rightmost string element ($\Searrow \textsc{r}$) corresponding to the c-structure node on which the annotations appear. Thus this label serves to effectively delimit the focused constituent.

[22] As with *PolarInt* above, note that *DFFoc* is simply a label; it does not situate discourse features in p-structure.

[23] We specify and require harmony for only the $\textsc{r}$ features in the s-string and p-string. This reflects the fact that focus marking in English is fundamentally right-edge based. We make no claims as to whether or not the same is true for other languages.

In the present example, the annotated node is an NP consisting of only a single word (*Norman*), so the leftmost and rightmost string elements dominated by the NP are the same. This is not the case when the phrase in focus consists of more than one word, as, for example, in instances of "broad" focus (see 55), and it is for this reason that separate specifications are required for the left edge and right edge of the phrase.

The principle in (59) specifies only the presence of a label, "DFFoc", as a member of the L and R sets in particular string elements. On its own, it does not say anything about the information structure status of the words in the focused phrase. In order to specify this, we must introduce a wellformedness constraint on strings, or a *string constraint* (see Lowe and Mycock 2014 and Chapter 6, Section 11.1). String constraints define the valid s-strings or p-strings for a language. A string constraint consists of a regular expression encoding the constraint, and a label which specifies the aspect of the string referred to by the constraint (here S-STRING, the other possibility being P-STRING). We make use of the symbol Σ, which represents a string element of any form.

The labels specified in (59) serve to delimit a span in the s-string: the leftmost s-string element in the span is marked by having the label "DFFoc" as a member of the L value set, while the rightmost one is marked by having the label "DFFoc" in its R value set. Our aim is to define a string constraint which requires every word in the relevant span to be marked in such a way that its meaning constructor appears in the FOCUS set at i-structure. For clarity, we define the following abbreviatory templates:

(60) a. INCLLEFT($\_\alpha$) $\equiv$ $\_\alpha \in_c (\bullet\ \text{L})$

b. INCLRIGHT($\_\alpha$) $\equiv$ $\_\alpha \in_c (\bullet\ \text{R})$

c. SDF($\_\alpha$) $\equiv$ $(\uparrow_\sigma\ \text{DF}) = \_\alpha$

d. NSDF($\_\alpha$) $\equiv$ $(\uparrow_\sigma\ \text{DF}) \neq \_\alpha$

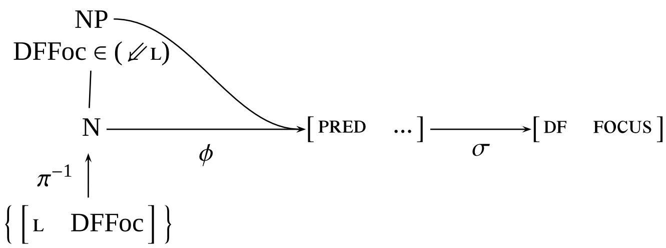
The template INCLLEFT ensures that its argument $\_\alpha$ is a member of the L set of the current string element, and similarly for the template INCLRIGHT. The template SDF specifies that its argument $\_\alpha$ is the value of the DF attribute of the s-structure $\uparrow_\sigma$, and NSDF specifies that the DF value of $\uparrow_\sigma$ is different from $\_\alpha$. These basic templates are used in the definition of the templates LFOCUS and RFOCUS:

(61) a. LFOCUS $\equiv$ @INCLEFT(DFFoc)
@SDF(FOCUS)

b. RFOCUS $\equiv$ @INCRIGHT(DFFoc)
@SDF(FOCUS)

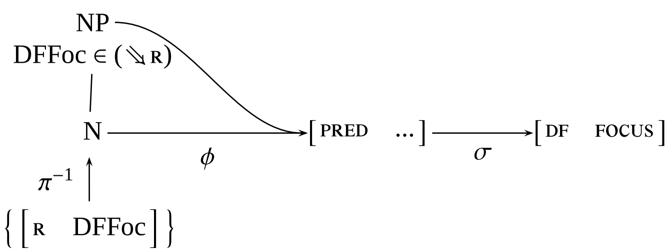
The f-description LFOCUS holds of a string element if "DFFoc" is a member of its L set, and the value of the DF attribute in its mother's semantic structure is FOCUS. Recall that we use the up arrow $\uparrow$ in lexical entries to refer to the c-structure node accessible from an s-string element via the π^{-1} relation (Section 4.1).

(62)



Similarly, RFOCUS holds of a string element if "DFFoc" is a member of its R set, and the DF value of its mother's semantic structure is FOCUS:

(63)



We then define the metacategory in (64), representing the Foc-Extent in terms of s-string items:

(64) $$\Sigma_{Foc} \equiv \{ \begin{array}{cccc|c} \Sigma & \Sigma^* & \Sigma & & \Sigma \\ @\text{LFOCUS} & @\text{SDF}(\text{FOCUS}) & @\text{RFOCUS} & & @\text{LFOCUS} \\ & & & & @\text{RFOCUS} \end{array} \}$$

The definition in (64) is a disjunction over two possible sequences: in both sequences, the leftmost element must be associated with the feature DF FOCUS at s-structure and must have the label "DFFoc" as a member of its L value set (in both cases, as a result of application of the template @LFOCUS); likewise in both sequences, the rightmost element must be associated with DF FOCUS at s-structure and must have the label "DFFoc" as a member of the R value set (by the application of the template @RFOCUS). The only difference between the two possibilities is whether the Foc-Extent is more than one s-string unit (that is, whether the s-string element with L {DFFoc} is different from the element with R {DFFoc}), or only one s-string unit with "DFFoc" as a member of both its L and R value sets. If there are more than two elements in the string, the elements that are neither leftmost nor rightmost must be associated with DF FOCUS at s-structure. This is achieved by application of the template @SDF(FOCUS).

We can use these definitions in formulating the s-string constraint in (65), which we call FOCUS. It allows for the appearance of several focused constituents in a string, each preceded and followed by string elements that are not in focus (marked with @NSDF(FOCUS)). The regular expression FOCUS string constraint constitutes one component of the s-string constraints that are relevant for English. It is intersected with all of the other s-string constraints for English to obtain the fully specified s-string wellformedness condition, as discussed in Chapter 6, Section 11.1.

(65) S-STRING FOCUS: $\left(\underset{@\text{NSDF}(\text{FOCUS})}{\Sigma^*} \quad \left(\Sigma_{Foc}\right) \quad \underset{@\text{NSDF}(\text{FOCUS})}{\Sigma^*} \right)^+$

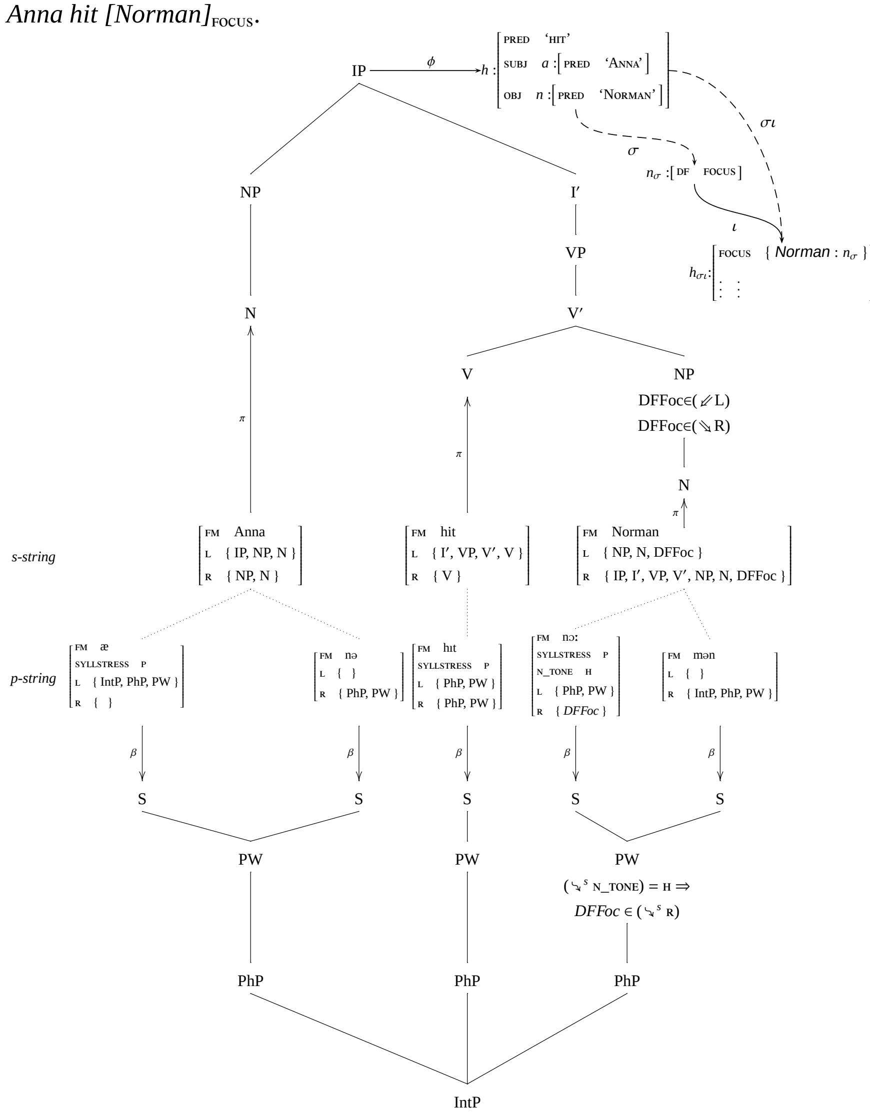
The rule in (65) permits one or more sequences consisting of any number of string elements that are not associated with FOCUS at s-structure (by the template @NSDF(FOCUS)), optionally followed by a sequence fitting the definition of Σ_{Foc}, followed by any number of string elements that are not associated with FOCUS at s-structure. That is, for any string in English the rule in (65) licenses one or more substrings of which every element is associated with DF FOCUS at s-structure, and of which the leftmost and rightmost elements are marked by the appearance of "DFFoc" in their L or R value sets respectively. Following the approach to information structure presented in Chapter 10, the association with DF FOCUS at s-structure has the effect that the meaning constructors corresponding to the s-string unit(s) in this sub-string appear in the FOCUS set at i-structure.

The p-structure, c-structure and s-string rules provided above are the basis for the analysis shown in (66) for the example given in (53).

In this utterance, the stressed syllable of the word 'Norman' /nɔː/ is associated with the Nuclear Tone (N_TONE H). The prosodic phrase structure rule in (58) may thus apply to the Prosodic Word dominating that syllable, in this case the final Prosodic Word in the p-structure pronounced /nɔː.mən/. As a result of (58) applying, the label *DFFoc* appears as a member of the set value of R in the syllable which has primary stress within this Prosodic Word, i.e. the first syllable of 'Norman'. On the syntactic side, the phrase-structure rule in (59) applies to the NP that corresponds to the s-string element 'Norman'. By this rule, the label "DFFoc" must appear in the L and R sets in the corresponding leftmost and rightmost s-string elements respectively, which in this case are the same element. By the string constraint in (65), the meaning constructor corresponding to this s-string element, that is the meaning constructor introduced in the lexical entry for the name *Norman*, appears in the FOCUS set at information structure. The principle of Interface Harmony requires that an s-string element which has a feature "DFFoc" in its R value set must be associated with a p-string element that has the feature *DFFoc* in its R value set. In (66), this requirement is satisfied, and the analysis succeeds. If, say, the c-structure rule in (59) were to apply not to the final NP in the c-structure but to the first one (meaning that *Anna* was in focus at information structure), the analysis would fail because "DFFoc" would appear in the R set in the s-string element *Anna* but would not be associated with a *DFFoc* feature in a corresponding p-string element. That is, prosodic and syntactic specifications are effectively required to match up, such that whichever prosodic element bears the Nuclear Tone necessarily corresponds to the syntactic element associated with the meaning constructor(s) that represent the focus at information structure.

Precisely the same set of rules can equally well account for instances of broad focus, where the Foc-Extent in the c-structure and s-string spans more than one word. Example (67) shows the analysis for (55a), an example of broad focus in which the Foc-Extent is *hit Norman*. The only difference from the structure in (66) is that the c-structure rule in (59) applies at the VP level, meaning that the

(66) *Anna hit [Norman]*$_{\text{FOCUS}}$.



label "DFFoc" appears in the L set in the s-string element corresponding to the word *hit*. This in turn means that the meaning constructor for *hit* appears in the FOCUS set at i-structure along with that for *Norman*, whose R set in the s-string contains the label "DFFoc" due to the annotation DFFoc $\in$ ($\searrow$ R) on the VP node.

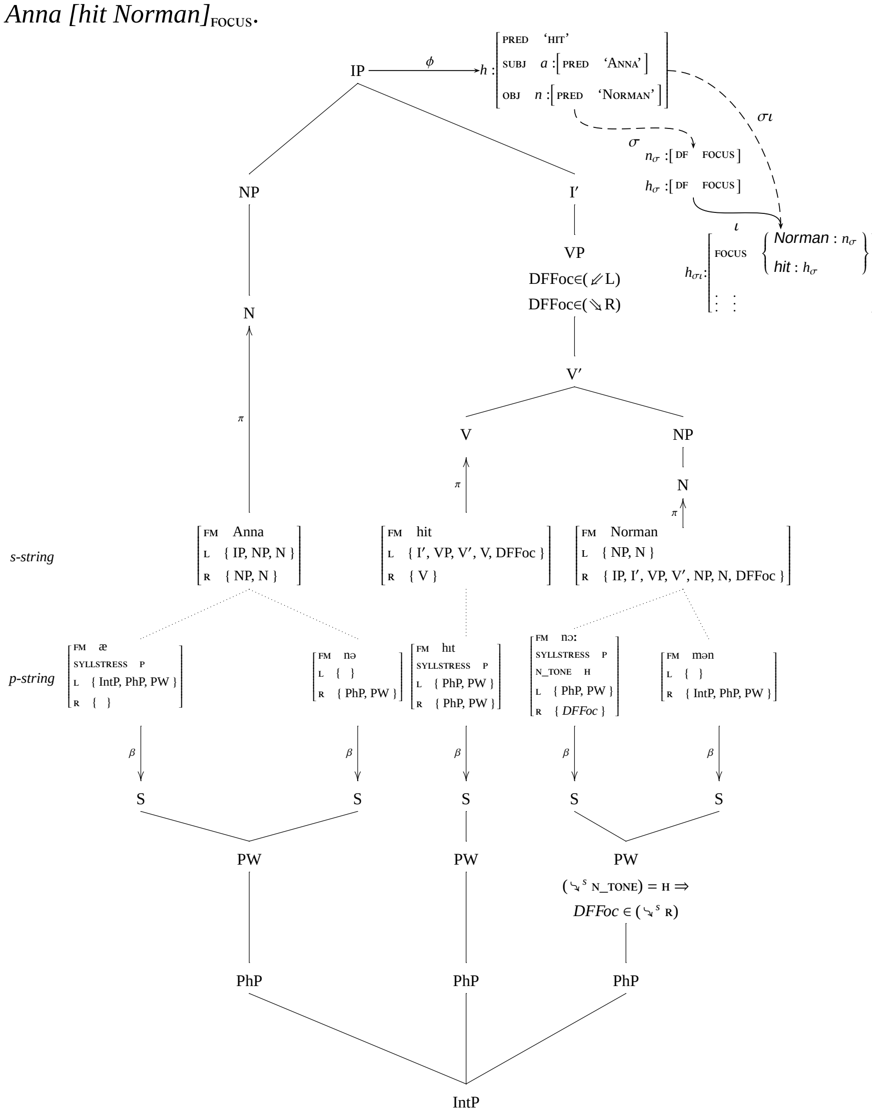
In this section, we have provided an analysis of prosodic focus marking in English. The approach which we have presented can also be used to analyze prosodic marking of this and other information structure categories crosslinguistically.

7. FURTHER READING AND RELATED ISSUES

Bögel (2012, 2013, 2014, 2015) has developed a distinct approach to prosody within the LFG framework whose formulation makes crucial reference to actual values of the acoustic characteristics of the speech signal. Bögel's proposals are in part influenced by the proposals of Dalrymple and Mycock (2011), but in certain respects depart significantly from other approaches to prosody within LFG. Bögel (2015) argues against a dependence on the prosodic hierarchy as a means of modeling p-structure, and proposes a model based on the 'p-diagram'. The 'p-diagram' represents speech as a series of *feature vectors*, each of which encodes the phonetic and phonological properties of a single syllable. Bögel's prosodic analysis is therefore fundamentally syllable-based, although in principle it could be made more fine-grained. The phonetic and phonological properties of individual syllables are accessible by other components of the grammar via a projection function. Bögel uses this approach in her analysis of prosodic resolution of syntactic ambiguities (see Bögel 2015, pages 70–77), as well as other phenomena.

Clitic positioning and the treatment of syntax-prosody mismatches are discussed by O'Connor (2002a,b, 2005a), Lowe (2011, 2016a) and Bögel (2014, 2015). Mycock (2006, 2007) presents an LFG approach to constituent question formation crosslinguistically which includes description and analysis of question intonation, and Mycock (2010) discusses the modeling of prosody and its interfaces, exemplifying the analysis with data from Hungarian. It must be noted that in these works the authors do not necessarily assume the version of LFG's parallel architecture that is adopted here.

(67) *Anna [hit Norman]*$_{\text{FOCUS}}$.



12

THE INTERFACE TO MORPHOLOGY

In this chapter, we examine the place of morphology in the LFG architecture. Work on the morphology-syntax interface in LFG (notably by Sadler and Spencer 2001 and Kaplan and Butt 2002) assumes a modular view of the morphological component, in line with the overall modular architecture of LFG: the morphological component has its own internal structure and obeys universal and language-particular constraints on word formation that need not be shared by other levels of structure. As Sadler and Spencer (2001) point out, this view accords well with Beard's Separation Hypothesis (Beard 1988, 1995), which argues for a separation between the representation of the phonological form of a word and the features encoding the morphosyntactic and morphosemantic contribution that the word makes.

Following Sadler and Spencer (2001), Kaplan and Butt (2002), Spencer (2006, 2013), and many others, we assume that the morphological component associates a word form with a set of features representing the morphological structure and grammatical contribution of the word, and that these features are interpreted at the interface of morphology with the rest of the grammar, producing the lexical entry for the word form. This view fits well with a *realizational* theory of morphology[1] as proposed by, among others, Anderson (1992), Stump (2001, 2002, 2006, 2012), and Brown and Hippisley (2012), though, like Sadler and Spencer (2001), Kaplan and Butt (2002), and Andrews (2005), our proposals are compatible not only with explicitly paradigm-based models, but with any morphological theory which relates words to feature sets encoding their grammatical properties and structure, including finite state theories of morphology (Kaplan and Kay 1994; Beesley and Karttunen 2003). Our work builds on and extends work on morphology and LFG by Butt et al. (1996a), Butt et al. (1996b), Frank and Zaenen (2002), Sadler and Nordlinger (2004), Andrews (2005), Otoguro (2006), Bond (2016), and especially Sadler and Spencer (2001) and Kaplan and Butt (2002).

1. THE MORPHOLOGICAL COMPONENT AND THE LEXICON

In the overall architecture of the grammar of a language, the morphological component serves to populate the lexicon with lexical entries. We first review our definition of the lexical entry, and we then show how the morphological component, together with a theory of the interface between morphology and the rest of the grammar, produces the complete set of lexical entries for a language.

1.1. The Lexical Entry

The full lexical entry for the plural noun *dogs* is given in (1), following the discussion in Chapter 11, Section 4.1. As elsewhere in the book, we use the familiar up and down arrows to refer to f-structures rather than the technically correct but more complex notation given in (23) of Chapter 11; recall that the s-form is the lexical representation specifying the s(yntactic)-string associated with a word, and the p-form is the lexical representation specifying the p(rosodic)-string contributed by that word.

(1) Full lexical entry for *dogs*:

s-form	(● FM) =	dogs
c-structure category	$\lambda(\pi(\bullet))$ =	N
f-description	(↑ PRED) =	'DOG'
	(↑ INDEX NUM) =	PL
	[dog] $\in (\uparrow_{\sigma\iota}\ (\uparrow_{\sigma}\ \textsc{df}))$	
	[pl] $\in (\uparrow_{\sigma\iota}\ (\uparrow_{\sigma}\ \textsc{df}))$	
p-form	/dɔgz/	

[1] Stump (2001) presents a taxonomy of morphological theories, contrasting *realizational* with *incremental* theories, and *lexical* with *inferential* theories. In terms of this taxonomy, we adopt an *inferential/realizational* approach.

For ease of presentation, and since our focus in this chapter is not on the details of syntactic representation or semantic composition, we will assume simplified f-descriptions containing only certain f-structure features, and omitting many details of f-structural constraints as well as semantic and other non-f-structural information. Thus, we will work with a simplified entry such as the one in (2), which we will use as a stand-in for the full entry in (1):

(2) Simplified entry, including only basic syntactic constraints:

s-form	(● FM) =	dogs
c-structure category	$\lambda(\pi(\bullet))$ =	N
f-description	(↑ PRED) =	'DOG'
	(↑ INDEX NUM) =	PL
p-form	/dɔgz/	

A note about terminology is in order. Morphologists often use the term "lexical entry" to refer to information associated with a lexeme rather than a word form, under the assumption that the contribution of a word form depends on the contribution of the lexeme, specified in the lexical entry for the lexeme, together with the features of the particular word form. We follow common LFG practice in using the term "lexical entry" to refer instead to a word form (here, the plural noun *dogs*) and its associated grammatical information, as in (1) and (2). We use the term *lexemic entry* to refer to a lexeme and its associated grammatical information. The aim of this chapter is to relate the lexical entry for a word form to the morphological feature set associated with the word form by the morphological component, given its lexemic entry.[2]

Kaplan and Butt (2002)[3] propose an alternative way of representing lexical entries, by means of a relation which they call *M*; to avoid confusion with the function $\mathcal{M}$ from c-structure nodes to their mother nodes in the tree, we call this relation $\mathcal{L}$. For Kaplan and Butt, $\mathcal{L}$ is a three-place relation involving a word form, a c-structure category, and an f-description, incorporating the same information as the traditional-style LFG lexical entries presented in Chapter 5:

(3) a. Traditional lexical entry (Chapter 5):

dogs N (↑ PRED) = 'DOGS'
(↑ INDEX NUM) = PL

b. The same lexical entry as an $\mathcal{L}$ relation (Kaplan and Butt 2002):

$\mathcal{L}$<dogs, N, {(↑ PRED) = 'DOGS', (↑ INDEX NUM) = PL}>

[2] In this chapter, we describe the task of producing the lexical entry for a word form, including its f-description, on the basis of its morphological features. Importantly, this is only for ease of exposition, and there is no directionality intrinsic to the theory; our overall aim is simply to define and constrain the relation between lexical entries and lexemic entries for a language in light of a theory of morphological realization for the language. Indeed, the opposite order of exposition is often adopted in the setting of Paradigm Function Morphology (Stump 2001), where a mapping from f-descriptions to morphological features is described.

[3] We follow the presentation in the unpublished Kaplan and Butt (2002) draft paper, which differs slightly from the version in the handout for the talk presented at the LFG02 conference.

We extend $\mathcal{L}$ to relate the different components of the enhanced lexical entry in (2): an s-form, a p-form, a possibly complex c-structure category (for definition and discussion of complex c-structure categories, see Chapter 3, Section 3.5), and an f-description. For us, then, $\mathcal{L}$ is a four-place relation:

(4) $\mathcal{L}$<s-form, p-form, category, f-description>

Rewriting the lexical entry in (2) in this format, the $\mathcal{L}$ relation for the plural noun form *dogs* is:

(5) The lexical entry in (2) as an $\mathcal{L}$ relation:

$\mathcal{L}$<dogs,
/dɔgz/,
N,
{(↑ PRED)=‘DOG’, (↑ INDEX NUM)=PL}>

The representation in (5) encodes exactly the same information as the representation in (2), but facilitates the discussion of the definition of $\mathcal{L}$ in the following. Our task, then, is to provide a way of defining the set of lexical entries $\mathcal{L}$ for a language, given an independently specified set of lexemic entries and an independently specified theory of morphological realization for the language.

In sum, the aim of this chapter is to elucidate the interface between the morphological component and the rest of the grammar, and to demonstrate how the set of lexical entries for a language is produced, given a set of lexemic entries and a theory of morphological realization for the language. We will provide a general framework which allows exploration of alternative theories of morphological realization and its interface with the rest of the grammar in an LFG setting.

1.2. Lexemic Entries and the Lexemic Index

We first provide some information about our expectations governing the structure of lexemic entries and how they are related. A lexemic entry contains information of the kind which we would expect to find in an ordinary dictionary. Spencer (2013) divides this information into the following four components:

(6) Lexemic entries according to Spencer (2013)

FORM:	the form of the root and any non-predictable stem forms
SYN:	syntactic information and requirements
SEM:	a representation of the meaning of the lexeme
LI:	a Lexemic Index, an arbitrary label identifying the lexeme

Our approach is broadly compatible with Spencer's view, though it is clear that word forms may be associated with information of other types as well: for example, the presence of certain affixes might mark a particular information structure role (Dalrymple and Nikolaeva 2011). Although the difference between the SYN and SEM components of the lexemic entry is important to the theory of lexical relatedness proposed by Spencer (2013), our primary concern in this chapter is to demonstrate how a realizational theory of morphology can be integrated into the architecture of LFG. Hence, in our discussion of the morphological component and its place in the grammar, we do not enforce a distinction in the lexemic entry between syntactic, semantic, and other kinds of information.

We follow Spencer (2013) in assuming that each lexemic root is associated with a unique identifier, its Lexemic Index (LI).[4] The LI cannot be equated with the semantic form, at least if we assume that the semantic form defines subcategorization requirements, since morphologically related forms with the same LI may have different subcategorization frames. Even if we assume that the LI corresponds to a subpart of the semantic form, the FN (see Chapter 5, Section 2.2.3), it is unclear whether identity of lexemic index for two different word forms has any consequences for compositional syntax or semantics, and thus whether the morphological derivational history of a lexeme should be encoded in the semantic form. For clarity, we provide mnemonic LIs such as DOG1 for the lexeme related to the noun forms *dog/dogs*, but we assume that the LI plays a role only within the morphological component, and is not visible to any other component of the grammar.

A lexemic entry is, then, a three-place relation *LE* involving (i) the form of the root and any non-predictable stem forms, together with morphological features encoding information about inflectional class, category, and other unpredictable features; (ii) an f-description that encodes syntactic, semantic, and other information associated with all word forms of the lexeme, filling the role of Spencer's SYN and SEM; and (iii) the Lexemic Index, which we abbreviate as LI.[5]

(7) General form of lexemic entry:

LE <root/idiosyncratic stem forms/features, f-description, LI>

For example, we assume that the lexemic entry that is relevant in the analysis of the plural noun *dogs* can be partially represented as follows, using the LI DOG1:[6]

(8) Partially specified lexemic entry for the lexeme DOG1:

LE <morphological features, {(↑ PRED)='DOG'}, DOG1>

The f-description that is associated with all forms of the lexeme DOG1 is {(↑ PRED)='DOG'}: this is the portion of the f-description that the word forms *dog* and *dogs* of this lexeme have in common. We now turn to a discussion of the morphological features which we expect to find as the first argument of this lexemic entry.

[4]The Lexemic Index is similar to the LexID proposed by Stump (2001).

[5]The lexemic entry relation *LE* is similar to what Andrews (2005) refers to as the *lookup function*, for which he uses the symbol $\mathcal{L}$.

[6]Recall that for simplicity, we use the PRED feature and its value to stand for the full f-description associated with a root. In a full treatment, the f-description in the lexemic entry would include more information, including (at least) the semantic content of the root: **[dog]** $\in$ ($\uparrow_{\sigma\iota}$ ($\uparrow_{\sigma}$ DF)), with an appropriate definition of the meaning constructor abbreviated as **[dog]**.

1.3. Morphological Features

For the lexeme DOG1, we propose the following full lexemic entry, including the appropriate set of morphological features as the first argument:

(9) Full lexemic entry for the lexeme DOG1:

LE <{M-ROOT:dog, M-ICLASS:1, M-CAT:NOUN}, {(↑ PRED)='DOG'}, DOG1>

Following Sadler and Spencer (2001) and Spencer (2006), we use the term *m-feature* for morphological features, and we use the *m*-prefix for particular m-features.

There are several types of m-features. Features that are relevant only within the morphological component are *morphomic features*. A standard example of a morphomic feature is inflectional class. Inflectional class is specified as a part of the lexemic entry, and we will see that it can play a role in determining the lexical entry for a word form. However, as a morphomic feature it is not visible outside the morphological component, and cannot be referenced in syntactic, semantic, prosodic, or other constraints.

Besides morphomic features, some m-features encode syntactic information: these are morphosyntactic m-features, relevant in defining c-structure or f-structure relations and constraints. Others involve morphological signaling of meaning: these are morphosemantic m-features. Still others are relevant at other levels of structure: for example, a word form may bear morphological marking to indicate its information structure role. A single m-feature can also play multiple roles, contributing information and constraints to more than one level of structure.

Thus, the lexemic entry in (9) associates the lexeme DOG1 with an m-feature M-ROOT which specifies the root form of the lexeme DOG1, an m-feature M-ICLASS which specifies inflectional class, and an m-feature M-CAT which specifies the lexical category of the lexeme. We do not rely on a particular theory of morphological realization or inflectional classes, and so we use the arbitrary integer 1 to represent the inflection class (M-ICLASS) of the lexeme DOG1.

The lexemic entry also includes all of the stems for a lexeme. For example, the lexemic entries for the verb roots *print* and *drink* are given in (10); *drink* differs from *print* in that its past tense form *drank* and past participle form *drunk* are irregular, and must be lexically specified. Again, we provide arbitrary inflectional class information for these lexemes:[7]

(10) a. Lexemic entry for PRINT:

[7]Unlike the lexemic entry for *dog* in (9), only the PRED FN value for the verbs *print* and *drink* is specified in (10). This is because the lexemic entry for a verb like *print* or *drink* produces both active and passive lexical entries, with different semantic forms, and the correlation between passive morphology and passive argument structure must be maintained: the semantic form for the active version of *print* is 'PRINT⟨SUBJ,OBJ⟩', and the passive version is 'PRINT⟨SUBJ,OBL$_{\text{AGENT}}$⟩'. The f-description for a verbal lexical entry, including the full semantic form linking thematic roles with grammatical functions, is specified as required by mapping theory (Chapter 9) on the basis of its functional features, including VOICE features. For an explanation of the structure of semantic forms and reference to parts of a semantic form by features such as FN, see Chapter 5, Section 2.2.3.

LE <{M-ROOT:print, M-ICLASS:2, M-CAT:VERB},
{(↑ PRED FN)=PRINT},
PRINT1>

b. Lexemic entry for DRINK:

LE <{M-ROOT:drink, M-STEM1:drank, M-STEM2:drunk, M-ICLASS:3, M-CAT:VERB},
{(↑ PRED FN)=DRINK},
DRINK1>

Depending on the theory of morphology that is assumed, different kinds of morphological information specified by different sets of m-features may be required. Again, since our analysis is compatible with a range of realizational morphological theories, we are agnostic about the content and representation of morphomic features such as inflectional class, and we often omit such features in the following discussion.

To summarize, every language specifies a set of lexemic entries *LE* which associate a Lexemic Index with a set of morphological m-features and an f-description. The detailed content of the m-features is dependent on the particular theory of morphological realization that is assumed, and we place no further constraints on the form of individual lexemic entries and the relations between them.

1.4. The Morphological Realization Relation *R*

The second relation relevant to defining $\mathcal{L}$ is the morphological realization relation *R*, which encodes a relation between a word form and its associated morphological features. Our modular theory of the interface between the morphological component and the rest of the grammar makes no assumptions about the precise nature of *R* or the internal details of the morphological component; in the current context, *R* is simply a means of associating m-features with p-forms and s-forms relative to a lexemic root.

Specifically, *R* is a set of four-place relations which we call *m-entries*, associating a Lexemic Index, an s-form, and a p-form with a set of m-features.

(11) General form of m-entry:

R <LI, s-form, p-form, m-features>

In the setting of Stump's (2001) version of Paradigm Function Morphology, *R* is the Paradigm Function. In more recent versions of the theory (Ackerman and Stump 2004; Stewart and Stump 2007; Stump 2016), m-features specify a cell in the *form paradigm*, and the s-form and p-form occupy a cell in the *realized paradigm*, related to the form paradigm by paradigm linkage principles.

For example, the m-entry for the plural noun *dogs* relates the Lexemic Index DOG1, the s-form 'dogs', the p-form /dɔgz/, and the set of m-features associated with plural nouns, {M-CAT:NOUN, M-NUM:PL}:

(12) M-entry for *dogs*:

R <DOG1, dogs, /dɔgz/, {M-CAT:NOUN, M-NUM:PL}>

To define the lexical entries for the word forms of a language, we require access to the complete set of m-entries as defined by the morphological realization component *R*.[8] The realization relation *R* for a language accounts for all aspects of the morphological realization of word forms in the language, encompassing a theory of derivational and inflectional morphology, and encoding generalizations about affix ordering, stress placement, and other morphological patterns for the language. The proper theory of *R* and its internal structure are of vital interest to morphological theory, but from the point of view of the interface between morphology and the rest of the grammar, we require only a theory which provides an empirically adequate and explanatory set of m-entries for a language, and we will not be concerned with the internal structure and definition of *R*.

1.5. The Functional Description Function *D*

We now turn to the main focus of this chapter: providing a means of interpreting the m-features which are associated via the realization relation *R* with a word form, producing the c-structure category and an f-description reflecting morphologically encoded information for the word form.[9] We use the abbreviation f-description$_M$, with subscript *M*, for the portion of the full f-description for a word form that is morphologically encoded. Our third function *D* maps a set of m-features provided by *R* to the appropriate c-structure category and f-description$_M$ for a word form.

(13) General form of the description function *D*:

D <Lexemic Index, m-features, category, f-description$_M$ >

D is what Kaplan and Butt (2002) call the "description function", and what Sadler and Nordlinger (2004) call a "lexical transducer" relating m-features and their values to grammatical specifications. In a Paradigm Function Morphology setting, *D* corresponds to what Stump (2002) calls *rules of paradigm linkage*, or (roughly) the correspondence relation between the *form paradigm* (pairing a lexeme with a set of m-features) and the *content paradigm* (pairing a lexeme with an f-description) in work by Stump (2015).

[8] We do not take a position on whether some or all lexical entries for morphologically invariant forms are stored separately, rather than being defined on the basis of m-entries for those forms: for example, whether there is an m-entry for the English determiner *the* from which the lexical entry for *the* is derived. It may be that such forms are in fact stored as underived lexical entries, and do not play a role in the morphological component.

[9] Marcotte and Kent (2010) explore the possibility of eschewing the *D* mapping and requiring the realizational component *R* to produce a full f-description rather than a set of m-features. We side with Sadler and Spencer (2001), Kaplan and Butt (2002), and many others in recognizing the need to distinguish between the m-features relevant within the morphological component and the f-description that is relevant outside it.

In Section 1.4, we saw that the realization relation *R* produces an m-entry which associates the set of m-features {M-CAT:NOUN, M-NUM:PL} with the s-form *dogs*, the p-form /dɔgz/, and Lexemic Index DOG1, as shown in (12). For the plural noun *dogs*, *D* interprets the m-features {M-CAT:NOUN, M-NUM:PL}, producing the c-structure category N and the f-description {(↑ INDEX NUM)=PL}:

(14) *D* <DOG1,
{M-CAT:NOUN, M-NUM:PL},
N,
{(↑ INDEX NUM)=PL}>

In this example, there is a simple mapping from the m-feature M-CAT:NOUN to the c-structure category N, and from the m-feature M-NUM:PL to the f-structure constraint (↑ INDEX NUM)=PL. We postpone a full discussion of the description function *D* to Section 3, where we will see that *D* can be considerably more complicated than this simple example indicates.

1.6. $\mathcal{L}$ Defined in Terms of *D*, *LE*, and *R*

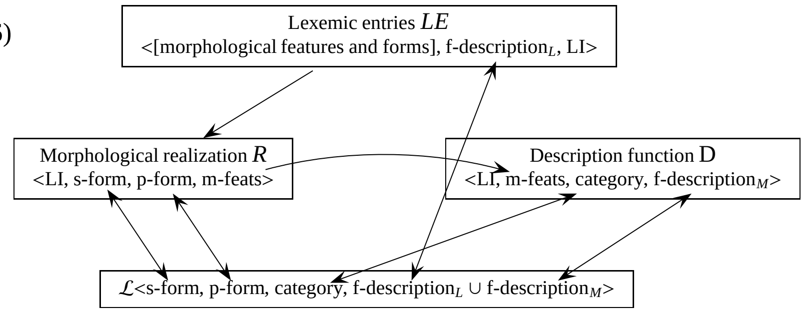
Still building on work by Kaplan and Butt (2002), we can now provide an explicit definition of $\mathcal{L}$ in terms of *D*, *LE*, and *R*.[10]

(15) $\mathcal{L}$ = {<s-form, p-form, category, f-description$_L \cup$ f-description$_M$>:
LE <m-features, f-description$_L$, LI> and
R <LI, s-form, p-form, m-features> and
D <LI, m-features, category, f-description$_M$ >}

In (15), $\mathcal{L}$ is the set of lexical entries for a language. Legitimate members of $\mathcal{L}$ are those which meet the conditions in the following three lines. First, a lexemic entry *LE* must provide a partial f-description$_L$ associated with a Lexemic Index LI and a set of m-features. Second, the morphological realization relation *R* muat include an m-entry relating the LI and m-features of that *LE* to an s-form and a p-form. Third, the description function *D* must map those m-features to a category and f-description$_M$. The f-description for the lexical entry is, then, obtained by combining (via set union, ∪) the f-description$_L$ intrinsic to the lexeme and the f-description$_M$ obtained from the m-features for the particular word form in question. We can represent the requirements in (15) graphically, as in (16):

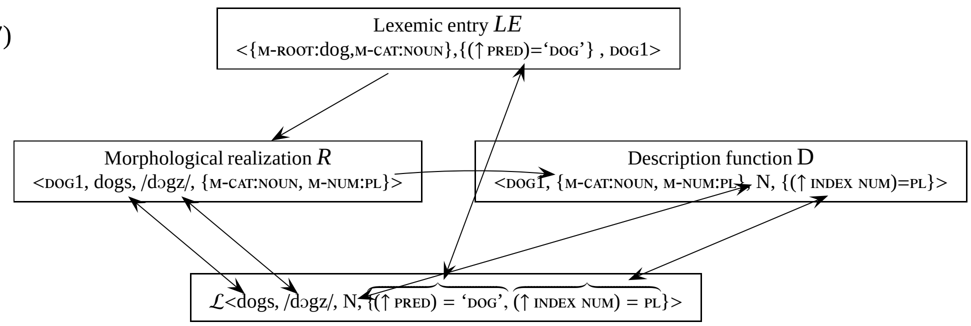
[10]The definition in (15) characterizes a set by describing its elements, as discussed in footnote 14 of Chapter 6. In (15), $\mathcal{L}$ is a set whose elements have the form <s-form, p-form, category, f-description$_L \cup$ f-description$_M$>; elements of that form are included in $\mathcal{L}$ if they satisfy the description in the next three lines.

(16)



For the word form *dogs*, we have the following, as desired:

(17)



As advocated by Kaplan and Butt (2002), m-features and the Lexemic Index are crucial in defining the description function *D*, but neither the Lexemic Index nor any of the m-features appear in the lexical entries $\mathcal{L}$ which are relevant for the rest of the grammatical system. It is only the information in the lexical entries in $\mathcal{L}$ — the s-form, p-form, c-structure category, and f-description — that is visible outside the morphological component. This maintains a clean separation between the morphological component and the other components of the grammar. In this way, our proposal aligns itself with the Principle of Morphology-Free Syntax (Pullum and Zwicky 1988; Zwicky 1992), and contrasts with proposals that reject the Lexical Integrity Principle, including Distributed Morphology (Halle and Marantz 1993; Embick and Noyer 2007) and the Exo-Skeletal Model (Borer 2013).

In sum, the following components are required for morphological analysis:

- A set of lexemic entries *LE* for a language, associating Lexemic Indices (LIs) with morphological roots, stems, and their idiosyncratic morphological features, and an f-description containing idiosyncratic syntactic, semantic, and other information and constraints for the lexeme.

- A morphological realization relation *R* for the language which relates full word forms and their associated m-features to a Lexemic Index.

- A description function D which interprets the m-features provided by the realization component R, producing fully specified lexical entries $\mathcal{L}$ for the word forms of the language.

The set of lexemic entries LE and morphological realization relation R are independently specified for each language, in conformance to a suitable realizational theory of morphology. In the remainder of the chapter, our focus is on the definition of the description function D, which constitutes the relation between morphology (sets of m-features) and the information and constraints that are relevant for the rest of the grammar.

2. MORPHOLOGICAL FEATURES AND MORPHOLOGICAL CLASSES

Our aim is to provide a framework which allows the linguist to define the proper D-mapping for a language in a clear and intuitive way, given a particular set of lexemic entries and a theory of the realization relation R for the language. In this section, we show how the D description function works by presenting some examples of mappings which are established by D between a set of m-features and a (possibly complex) c-structure category and f-description. The examples in this section are intended as simple illustrations of the range and types of D-mappings that may be required, under various alternative assumptions about the best way of treating a particular grammatical construction or the grammatical consequences of a particular morphological alternation. Of course, there may be alternative lexemic entries, alternative realization relations R, or alternative D-mappings which could be argued to provide a more satisfying analysis of the phenomena under discussion: the purpose of the discussion in this section is not to advocate these particular analyses over alternatives, but to illustrate and exemplify various kinds of D-mappings in a simple and intuitive way. A focus of future research is to examine the mappings presented here in more detail; in fact, it may be possible and desirable to adopt a more constrained theory of the D-mapping, according to which some of these types of mappings are dispreferred or disallowed.

In line with the overall architecture of LFG, our approach is modular in the sense that any particular theory of the realization relation R for a language is likely to be compatible with several different possibilities for syntactic and semantic analysis of the language. An example of this is presented in Section 2.2, where two alternative syntactic analyses of the English “affix hopping” pattern are considered in the context of the same theory of morphological realization R for English. These approaches differ from ours in appealing to a separate *morphosyntactic structure*; further, one analysis also assumes complex c-structure categories. We point out how the D mapping is defined differently in these two settings. We also provide examples of mappings involving lexical exceptions, taking the Lexical Index as well as m-features into account; mappings which take into account more than one m-feature; default mappings involving privative features, in which an f-description is introduced in the absence of an m-feature; and mappings involving complex m-feature specifications. Our theory of the *D*-mapping as the interface between the morphological component and the rest of the grammar must be flexible enough to allow expression of alternative grammatical analyses on the basis of the same morphological realization relation *R*, and also to encompass alternative assumptions about the nature of *R*.

In this section, rather than representing all four components of *D*, we abbreviate by informally indicating an association represented as $\stackrel{D}{\Rightarrow}$ between an m-feature or set of m-features and the corresponding c-structure category or f-description. We provide a precise formal definition of *D* in Section 3.

2.1. Simple *D*-Mappings

Many m-features specify information that is relevant for syntax or semantics. Often, for example, the morphological form of a noun or pronoun transparently signals its f-structure case; morphologically accusative nouns contribute the m-feature M-CASE:ACC, and this corresponds to a specification of accusative case at f-structure.[11] This means that the description function *D* must establish the correspondence given in (18) between the m-feature M-CASE:ACC and an equation specifying the value ACC for the CASE attribute at f-structure.

(18) Typical *D*-mappings:

$$\text{M-CASE:ACC} \stackrel{D}{\Rightarrow} (\uparrow \text{CONCORD CASE}) = \text{ACC}$$

$$\text{M-NUM:PL} \stackrel{D}{\Rightarrow} (\uparrow \text{INDEX NUM}) = \text{PL}$$

2.2. C-Structurally Relevant M-Features

As has been known since Chomsky's (1957) formulation of the Affix Hopping transformation, English auxiliaries select a particular form of their verbal complements: progressive *be* selects the present participial form of the following verb, perfect *have* selects the past participial form of the following verb, and so on.

(19) a. *David is swimming.*

b. *David has swum.*

c. *David has been swimming.*

d. *David must be swimming.*

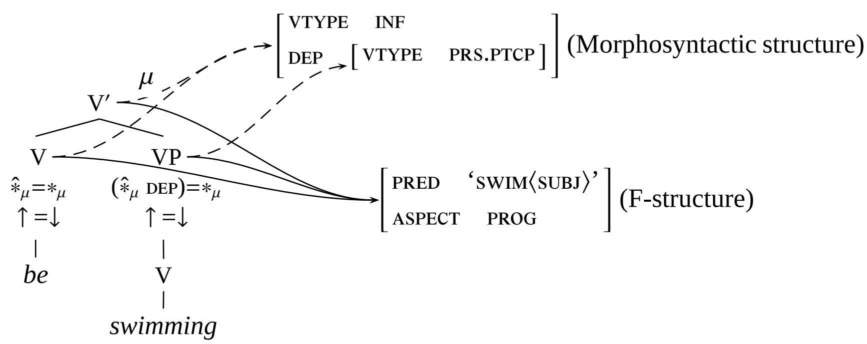
e. **David have is swum.* / **David has swimming.*

[11]Chapter 2, Section 5 provides more discussion of the structure and representation of the values of features such as CASE and NUM; here we provide simplified atomic values such as ACC and PL.

In their analysis of auxiliary selection, Butt et al. (1996a) and Butt et al. (1996b) propose a new projection from c-structure, *morphosyntactic structure*. Building on this work, but adopting a slightly different projection architecture, Frank and Zaenen (2002) propose an alternative analysis in which morphosyntactic structure is projected from f-structure rather than c-structure, and which also requires the use of complex c-structure categories. As noted in Chapter 7, Section 1.1, we do not adopt morphosyntactic structure as a level of representation elsewhere in this book; we present these two analyses here simply as illustrations of how the *D*-mapping works, and in particular to show how different definitions of the *D*-mapping from the same m-features give rise to different lexical entries, depending on the syntactic analysis that is assumed.

Butt et al. (1996a) and Butt et al. (1996b) argue that Affix Hopping patterns should not be treated in terms of complementation or embedding at functional structure, and propose to encode verbal dependencies at morphosyntactic structure, which on their approach is related to c-structure through a projection function μ, represented in (20) as a dashed arrow:

(20) *be swimming* according to Butt et al. (1996a,b):



On Butt et al.'s analysis, *be swimming* contributes a monoclausal f-structure: the V and VP daughters of V′ are f-structure coheads, each annotated with ↑ =↓. The requirement for the complement of *be* to appear in present participial form holds at morphosyntactic structure.

Butt et al.'s lexical entries for *be* and *swimming* are:

(21) Lexical entries according to Butt et al. (1996a):

$\mathcal{L}$<be, /bi/, V, {($\hat{*}_\mu$ VTYPE)=INF, ($\hat{*}_\mu$ DEP VTYPE) $=_c$ PRS.PTCP}>

$\mathcal{L}$<swimming, /swɪmɪŋ/, V, {(↑ ASPECT)=PROG, ($\hat{*}_\mu$ VTYPE)=PRS.PTCP}>

According to Butt et al., morphosyntactic structure is accessible via the μ projection function from the nodes in the c-structure, as shown in (20). As usual, $*$ refers to the current phrase structure node, and $\hat{*}$ refers to the mother of the current node (as explained in Chapter 5, Section 3.1); thus, in the lexical entries in (21) and in the annotations on the tree in (20), $\hat{*}_\mu$ refers to the μ-projection of the mother node, i.e. the morphosyntactic structure corresponding to the mother node, and $*_\mu$ refers to the μ-projection of the current node. According to these lexical entries and phrase structure annotations, then, progressive *be* requires its verbal dependent DEP to be a present participle at morphosyntactic structure, with the value PRS.PTCP for the VTYPE attribute. *Swimming* is specified with the value PRS.PTCP at morphosyntactic structure, and the $(\hat{*}_\mu\ \text{DEP}) = *_\mu$ constraint on the VP node ensures that the morphosyntactic structure of *swimming* appears as the value for the DEP feature. This approach provides a means of handling morphosyntactic dependencies by a mechanism similar to complementation at f-structure, but without assuming embedding at f-structure.

In this setting, we assume the m-entry for *swimming* in (22), and consider the *D*-mapping which produces the lexical entry for *swimming* in (21) from this m-entry:

(22) M-entry for *swimming*:

R <SWIM1, swimming, /swɪmɪŋ/, {M-CAT:VERB, M-VTYPE:PRS.PTCP}>

For clarity, we have provided the same value PRS.PTCP for the m-feature M-VTYPE in (22) and the VTYPE feature at morphosyntactic structure in (20). Importantly, these features and their values have a very different status: the m-feature M-VTYPE:PRS.PTCP in (22) is visible and relevant only within the morphological component, and plays an crucial role in defining the lexical entry for the word form *swimming*, while the VTYPE feature in (20) is relevant in defining and constraining syntactic dependencies involving verbs.

Given the m-entry in (22), Butt et al.'s analysis requires the morphosyntactic M-VTYPE feature that is contributed by *swimming* to correspond to a VTYPE feature at morphosyntactic structure via the μ mapping, and an ASPECT feature at f-structure; this allows the required dependencies to be established.

(23) *D* mapping for f-description according to Butt et al. (1996a,b):

$$\text{M-VTYPE:PRS.PTCP} \overset{D}{\Rightarrow} \{(\hat{*}_\mu\ \text{VTYPE}) = \text{PRS.PTCP},\ (\uparrow \text{ASPECT}) = \text{PROG}\}$$

Butt et al.'s analysis also requires the M-CAT feature for verbal forms to map to the phrase structure category V:

(24) *D* mapping for phrase structure category according to Butt et al. (1996a,b):

$$\text{M-CAT:VERB} \overset{D}{\Rightarrow} \text{V}$$

In this way, Butt et al.'s analysis enforces "affix hopping" requirements at morphosyntactic structure while maintaining a simple, monoclausal f-structure with no embedding.

It is possible for the same theory of morphological realization, and in particular the same m-entry in (22), to underpin an analysis of the English auxiliary system that makes very different syntactic assumptions. Frank and Zaenen (2002) provide an alternative analysis of auxiliary selection, illustrated primarily for French, which assumes a different relation between morphosyntactic structure and f-structure, and which also appeals to complex c-structure categories; see Chapter 3, Section 3.5 and Chapter 5, Section 1.4 for definition and discussion of complex categories, including parametrized complex categories. Frank and Zaenen's proposal differs from Butt et al.'s in the inventory of features that appear in morphosyntactic structure: according to Frank and Zaenen, morphosyntactic structure contains a number of additional features not treated by Butt et al., including person, number, gender, and case. Constraints on these features are generally stated in terms of f-structure relations rather than c-structure configuration: verbs show agreement in person, number, and/or gender with their subjects or objects, for example, and case is often an indication of f-structure role. According to Frank and Zaenen (2002), then, morphosyntactic structure is best treated as directly related to f-structure rather than c-structure, since this allows easy reference to f-structural relations in characterizing morphosyntactic dependencies such as agreement and case assignment. For a discussion of the grammatical architecture that Frank and Zaenen assume, see Chapter 7, Section 1.1.

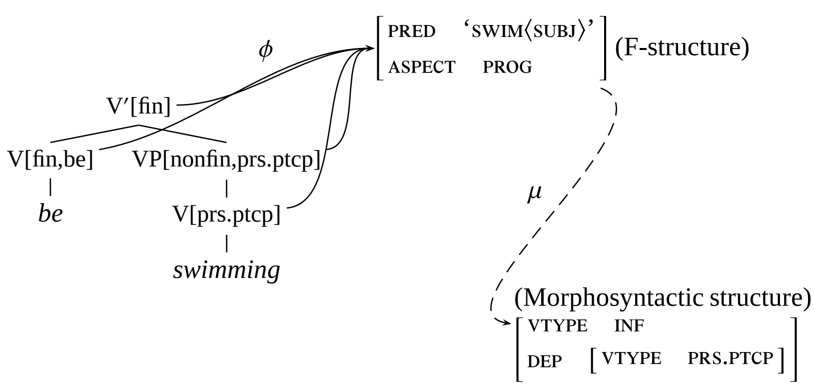
Frank and Zaenen (2002) redefine μ as a function from f-structures (rather than nodes of the c-structure) to morphosyntactic structures:

(25) The μ projection function:

Butt et al. (1996a), Butt et al. (1996b): $\hat{*}_\mu = \mu(\hat{*})$
Frank and Zaenen (2002): $\uparrow_\mu = \mu(\phi(\hat{*}))$

Adapting Frank and Zaenen's analysis of French auxiliaries to conform more closely to Butt et al.'s assumptions about the structure of the English verb phrase, we obtain this configuration:

(26) *be swimming*, following Frank and Zaenen (2002):



Since Frank and Zaenen assume that morphosyntactic structure is directly related to f-structure and only indirectly related to c-structure, their approach cannot take advantage of c-structural embedding relations to control auxiliary sequencing. Instead, Frank and Zaenen propose a combination of constraints involving morphosyntactic features and complex c-structure categories to constrain the position and morphological form of verbs in the verbal complex.

As discussed in Chapter 3, Section 3.5 and Chapter 5, Section 1.4, complex categories allow certain features to be realized as a component of a complex c-structure category, and parametrized rules allow for these features to be passed through the tree. For example, the parametrized phrase structure rule in (27) states that a V′ with a finiteness value represented as _ftness dominates a V with form 'be' and the same finiteness value _ftness as the V′, followed by a VP headed by a nonfinite present participial verb. This rule ensures that progressive *be* is followed by a present participial complement, as in *be swimming*.

(27) V′ phrase structure rule according to Frank and Zaenen (2002):

V′[_ftness] ⟶ V[_ftness,be] VP[nonfin,prs.ptcp]

On Frank and Zaenen's approach, then, *be* and *swimming* have the lexical entries in (28), containing specifications of VTYPE for *be* and DEP VTYPE for *swimming* at morphosyntactic structure, as well as complex c-structure categories:

(28) Lexical entries according to Frank and Zaenen (2002):

$\mathcal{L}$<be, /bi/, V[fin,be], {($\uparrow_\mu$ VTYPE)=INF, ($\uparrow_\mu$ DEP VTYPE) $=_c$ PRS.PTCP}>

$\mathcal{L}$<swimming, /swɪmɪŋ/, V[prs.ptcp], {(($\uparrow$ ASPECT)=PROG, ($\uparrow_\mu$ DEP VTYPE)=PRS.PTCP}>

We again assume the m-entry for *swimming* given in (22), but Frank and Zaenen's approach requires a different *D*-mapping from m-features to f-descriptions. On this approach, the description function *D* must establish the following correspondence between the set of m-features for *swimming* and a complex c-structure category:

(29) *D*-mapping to complex c-structure category according to Frank and Zaenen (2002):

{M-CAT:VERB, M-VTYPE:PRS.PTCP} $\stackrel{D}{\Rightarrow}$ V[prs.ptcp]

As this example illustrates, more than one m-feature may be involved in a single mapping relation: here, the m-features {M-CAT:VERB, M-VTYPE:PRS.PTCP} are involved in a single *D*-mapping specification to the complex category V[prs.ptcp].

Frank and Zaenen's analysis also involves constraints on morphosyntactic structure and f-structure. This means that the same M-VTYPE feature as in (29) maps to the following f-description:

(30) *D*-mapping to f-description according to Frank and Zaenen (2002):

M-VTYPE:PRS.PTCP $\stackrel{D}{\Rightarrow}$ {($\uparrow$ ASPECT)=PROG, ($\uparrow_\mu$ DEP VTYPE)=PRS.PTCP}

Note, then, that the same m-features can be relevant in two different aspects of the *D*-mapping: here, the same m-feature, M-VTYPE, is involved in determining both a complex c-structure category (29) and an f-description (30).

2.3. Mixed Categories

Spencer (2013, pages 122-123) discusses the Russian noun *stolovaja* ‘dining room’, which historically derives from an adjective, and is synchronically a noun that inflects as an adjective (see also Baerman et al. 2005). This can be seen by inspecting the paradigms for the noun *stolovaja* ‘dining room’, the adjective *bol′šoj* ‘big’, and the noun *lampa* ‘lamp’:

(31)

	Noun	Adjective	Noun
	‘dining room’	‘big’	‘lamp’
NOM	stolov-aja	bol′š-aja	lamp-a
ACC	stolov-uju	bol′š-uju	lamp-u
GEN	stolov-oj	bol′š-oj	lamp-i
DAT	stolov-oj	bol′š-oj	lamp-e
INS	stolov-oj	bol′š-oj	lamp-oj
PREPOSITIONAL	stolov-oj	bol′š-oj	lamp-e

As Spencer shows, *stolovaja* belongs to a class of words that are syntactically nouns, but morphologically adjectives; he refers to such forms as ‘mixed lexical categories’.[12] We assume the m-entries in (32) for the nominative forms. For *bol′š-aja* (with M-CAT:ADJ) and *lamp-a* (with M-CAT:NOUN), the M-CLASS feature has value REGULAR; in contrast, *stolovaja* patterns morphologically as an adjective, with the m-feature M-CAT:ADJ, but is marked as a mixed category with the syntactic behavior of a noun by the feature M-CLASS:MIXED-A-N.

(32) M-entries for Russian nominative word forms:

R <STOLOV1, stolovaja, /stɐlovəjə/,
{M-CAT:ADJ, M-CLASS:MIXED-A-N, M-CASE:NOM}>

R <BOLŠ1, bol′šaja, /bɐlʲʂajə/,
{M-CAT:ADJ, M-CLASS:REGULAR, M-CASE:NOM}>

R <LAMP1, lampa, /lampə/,
{M-CAT:NOUN, M-CLASS:REGULAR, M-CASE:NOM}>

Given these m-entries, the *D*-mapping rule in (33) produces the correct category for these verb forms; notably, for the mixed category *stolovaja* with m-feature M-CLASS:MIXED-A-N, the M-CAT:ADJ m-feature maps to the c-structure category N:[13]

(33) a. C-structure category N for a Russian mixed category inflecting as an adjective (for example, *stolovaja*):

[12]The term ‘mixed category’ is also used in a different sense, to refer to categories such as the English gerund, which exhibit both nominal and verbal syntactic characteristics simultaneously (Bresnan 1997; Bresnan and Mugane 2006; Seiss 2008; Lowe 2017a). ‘Mixed lexical categories’ in Spencer’s sense are categories which have morphological characteristics of one category, but syntactic characteristics of another category.

[13]If we assume a morphological theory which makes use of privative features and defaults, the mapping for the regular nouns *bol′šaja* and *lampa* could be treated as a default mapping (Section 2.6).

m-cat:adj $\overset{D}{\Rightarrow}$ N in the presence of the m-feature m-class:mixed-a-n.

b. C-structure category A for a regular category inflecting as an adjective (for example, *bol′šaja*):

m-cat:adj $\overset{D}{\Rightarrow}$ A in the presence of the m-feature m-class:regular.

c. C-structure category N for a regular category inflecting as a noun (for example, *lampa*):

m-cat:noun $\overset{D}{\Rightarrow}$ N in the presence of the m-feature m-class:regular.

Lowe (2017a) proposes a parallel *D*-mapping rule which provides an account of participles, a category of word which is syntactically verbal but morphologically adjectival.

2.4. Deponency

Börjars et al. (1997) and Sadler and Spencer (2001) discuss the Latin verb *loquor* 'I speak', which has the morphological form of a passive verb but is syntactically active, as can be seen by comparing the forms of *loquor*, with active voice, to the active and passive forms of *lego* 'I read'. This verb illustrates *deponency* (Baerman 2007), a mismatch in which a word has a form implying a particular category (here, passive voice) but realizing a different category (active voice).

(34)

	DEPONENT ACTIVE	NON-DEPONENT ACTIVE	NON-DEPONENT PASSIVE
PRESENT	loquitur 'he speaks'	legit 'he reads'	legitur 'it is read'
IMPERFECT	loquebatur 'he spoke'	legebat 'he read'	legebatur 'it was read'
FUTURE	loquetur 'he will speak'	leget 'he will read'	legetur 'it will be read'

We assume that the realization relation *R* contributes an m-feature m-voice encoding morphological voice. We must, then, define the *D*-mapping in such a way that for deponent verbs (with m-feature m-class:deponent-voice), the m-feature for passive morphological form maps to an f-description specifying active voice. For non-deponent verbs (with m-feature m-class:regular), morphological voice matches syntactic voice. According to this analysis, the third-person singular present tense forms of these verbs have the following m-entries:

(35) M-entries for Latin verb forms:

R <LOQ1, loquitur, /lokʷɪtur/,
{M-CAT:VERB, M-CLASS:DEPONENT-VOICE, M-VOICE:PASS, M-PERS:3, M-NUM:SG, M-TENSE:PRES}>

R <LEG1, legitur, /legitur/,
{M-CAT:VERB, M-CLASS:REGULAR, M-VOICE:PASS, M-PERS:3, M-NUM:SG, M-TENSE:PRES}>

The *D*-mapping rules given in (36) produce the correct voice specification for these word forms: active voice for the deponent verb *loquitur*, and passive voice for the regular verb *legitur*.

(36) a. Passive form, active voice for deponent verbs (for example, *loquitur*):

M-VOICE:PASS $\stackrel{D}{\Rightarrow}$ ($\uparrow$ VOICE)=ACTIVE in the presence of the m-feature M-CLASS:DEPONENT-VOICE.

b. Passive form, passive voice for regular verbs (for example, *legitur*):

M-VOICE:PASS $\stackrel{D}{\Rightarrow}$ ($\uparrow$ VOICE)=PASS in the presence of the m-feature M-CLASS:REGULAR.

2.5. Lexical Exceptions: F-Description$_M$ Dependent on Lexemic Index

We include the Lexemic Index as a component of the description function *D* in order to allow for the possibility that the interpretation of an m-feature or a set of m-features varies idiosyncratically for different lexemes, and that this is best analyzed by encoding a dependence in the *D*-mapping on the Lexemic Index.

For example, Acquaviva (2008, page 19) proposes that the word form *measles* is exceptional in being morphologically plural (involving suffixation of plural *-s* to a base, and so carrying the m-feature M-NUM:PL) but syntactically singular, and so bearing the f-description ($\uparrow$ INDEX NUM)=SG. That *measles* is syntactically singular is shown by its requirement for singular verb agreement:

(37) *Measles is/*are a terrible disease.*

On this view, *measles* is a deponent noun, morphologically plural but syntactically singular. Support for the view that *measles* is morphologically plural, consisting of the root *measle* followed by plural *-s*, is provided by attested examples of the uninflected form *measle* as the first member of a noun-noun compound:

(38) a. *New needle-free **measle vaccine** 'could save thousands of children's lives'* (headline in *The Telegraph*, 17 Aug 2009)

b. *...it is reasonable because though we have never found a **measle germ** associated with **measle-symptoms** we have in cases with like symptoms found, not indeed **measle germs**, but things of the same sort...* (Wisdom 1968)

One way to capture Acquaviva's analysis in our setting is by assuming that the m-feature m-num:pl maps to the syntactic feature (↑ index num)=pl in most cases, but with particular lexically specified exceptions involving reference to particular lexemic entries: if the LI is measle1 or a handful of other syntactically singular nouns with plural morphology, m-num:pl maps to (↑ index num)=sg. Such an analysis requires the following m-entries and *D*-mapping rule:

(39) M-entries for English noun forms:

R <measle1, measles, /miːzl̩z/, {m-cat:noun, m-num:pl}>

R <dog1, dogs, /dɔgz/, {m-cat:noun, m-num:pl}>

(40) *Measles* as a lexical exception:

m-num:pl $\overset{D}{\Rightarrow}$ (↑ index num)=sg if LI = measle1,
otherwise m-num:pl $\overset{D}{\Rightarrow}$ (↑ index num)=pl

This analytic possibility may not arise, depending on the particular theory of morphological realization and the morphology-syntax-semantics interface that is adopted. There are two alternative analytic possibilities that do not involve reference to the LI. First, it may be preferable to analyze *measles* as a root that belongs to a particular (very small) inflectional class, consisting of deponent nouns that are morphologically plural but syntactically singular. Under this analysis, the m-feature m-class for this class, rather than the LI for the lexemic entry, would be important in the *D*-mapping for *measles*. Second, if the realization relation *R* specifies *measles* as having m-num:sg even though it bears plural morphology, the definition of *D* need not take the LI into account. If alternative accounts which do not involve reference to the LI are shown to be available and preferable for all word forms, we need not include the LI as a component of the description function *D*. On the other hand, if the interpretation of a set of m-features is best analyzed as varying according to the LI, we must take the LI into account in our definition of *D*. Future work will show which hypothesis is viable, and whether the LI must be taken into account in at least some cases of the *D*-mapping.

2.6. Feature Defaults

Some morphological theories use privative features: that is, the absence of a feature is interpreted as indicating the presence of some grammatical property. To allow for this possibility, the *D*-mapping must be formulated so as to permit the introduction of a particular f-description if no m-feature of a certain type is present.[14] For example, we might assume that the realization relation *R* provides

[14] Note that we neither advocate nor reject the use of privative features or defaults in defining the *D*-mapping relation; whether or not such rules are needed depends on the theory of the morphological realization relation *R* that is adopted and the syntactic rules and constraints for the language. Privative features are not used in Paradigm Function Morphology (Stump 2001), and so feature default rules of this type are not relevant in a PFM setting.

a privative m-feature M-NUM:PL for plural nouns, but no m-feature for singular nouns: nouns are assumed to be syntactically singular if the plural m-feature does not appear. In other words, according to this view plural nouns such as *dogs* are associated with the m-feature M-NUM:PL, and singular nouns such as *dog* do not have a M-NUM feature. This analysis assumes m-entries like the following:

(41) M-entries for English noun forms:

R <DOG1, dog, /dɔg/, {M-CAT:NOUN}>

R <DOG1, dogs, /dɔgz/, {M-CAT:NOUN, M-NUM:PL}>

Under these assumptions, we require a default rule which applies when the M-NUM feature is absent:

(42) Singular number as a morphological default for nouns:

Introduce the f-description {($\uparrow$ INDEX NUM)=SG} if there is an m-feature M-CAT:NOUN but no M-NUM m-feature in the m-description.

In Section 3.2.3 below, we will see how to express default rules within the formal framework that we adopt.

2.7. Complex M-Feature Specifications

According to some theories of the morphological realization relation *R*, m-features can have a complex structure involving reference not to the f-structure denoted by $\uparrow$, but to a different f-structure related in a specified way to $\uparrow$. Our definition of the *D* mapping must, then, allow for the proper treatment of such complex m-feature specifications. For example, Stump (2001) proposes m-features such as the following:

(43) Example: Complex m-feature, Stump (2001)

AGR(SU):{PERS:1, NUM:PL}

Here, a set of m-features is relevant for subject agreement for inflected verbs, encoding first person plural subject agreement. Thus, the *D* mapping must map a complex m-feature of this form to the following f-description:

(44) *D*-mapping for a complex m-feature:

$$\text{AGR(SU):\{PERS:1, NUM:PL\}} \overset{D}{\Rightarrow} \{(\uparrow \text{SUBJ INDEX PERS})=1, (\uparrow \text{SUBJ INDEX NUM})=\text{PL}\}$$

3. THE DESCRIPTION FUNCTION *D*

We have seen that the set of lexical entries $\mathcal{L}$ is determined for a language on the basis of a set of lexemic entries *LE*, a set of m-entries defined by the morphological realization relation *R*, and the description function *D* mapping from m-features to a c-structure category and f-description. The realization relation *R* is provided by a separately specified theory of morphological realization. Lexemic entries *LE* include f-descriptions which are structured according to the theory of syntax, semantics, information structure, and prosody that we discuss elsewhere in this book. The description function *D* constitutes the interface between the morphological component and the rest of the grammar, since it defines the relation between the m-features for a word form, which are invisible outside the morphological module, and the phrase structure category and f-description that appear in its lexical entry.

3.1. Previous Definitions of *D*

Previous approaches have assumed that the f-description corresponding to a set of m-features can be constructed by examining one m-feature at a time, mapping each m-feature to a partial f-description independent of the presence or absence of other m-features. This is, for example, how Kaplan and Butt (2002) define *D*, and how Andrews (2005) defines his version of *D* for features not involved in case stacking (Section 3.3.6). Simple definitions such as these do not allow for dependencies among m-features, nor for defaults: they do not allow the introduction of an f-description in the absence of an m-feature, for example.

Kaplan and Butt (2002) analyze the ambiguous German noun *Kätzchen* 'kitten/kittens' by means of two different m-entries, one associated with singular number (with syncretic nominative/dative/accusative case) and the other associated with plural number (with syncretic nominative/genitive/dative/accusative case). Translating their analysis into the current setting, the s-form and p-form for the two m-entries are the same, but the m-features differ in terms of the morphological specification of number (M-NUM) and case (M-CASE):

(45) *Kätzchen* (Kaplan and Butt 2002):

R <KÄTZCHEN1, Kätzchen, /kɛtsçən/,
{M-ROOT:KATZE, M-CAT:NOUN, M-GEND:NEUT, M-NUM:SG, M-CASE:NOM/DAT/ACC}>

R <KÄTZCHEN1, Kätzchen, /kɛtsçən/,
{M-ROOT:KATZE, M-CAT:NOUN, M-GEND:NEUT, M-NUM:PL, M-CASE:NOM/GEN/DAT/ACC}>

Kaplan and Butt propose that the description function *D* maps from individual m-features to component parts of the f-description for a word form:

(46) Kaplan and Butt's (2002) description function *D* for each m-feature:

$$
\begin{array}{rcl}
D(\text{m-root:Katze}) & = & \{(\uparrow \text{pred}) = \text{`Katze'}\} \\
D(\text{m-cat:noun}) & = & \{\text{N}, (\uparrow \text{ntype}) = \text{count}\} \\
D(\text{m-gend:neut}) & = & \{(\uparrow \text{concord gend}) = \text{n}\} \\
D(\text{m-num:sg}) & = & \{(\uparrow \text{index num}) = \text{sg}\} \\
D(\text{m-num:pl}) & = & \{(\uparrow \text{index num}) = \text{pl}\} \\
D(\text{m-case:nom/dat/acc}) & = & \{(\uparrow \text{concord case}) \in \{\text{nom,dat,acc}\}\} \\
D(\text{m-case:nom/gen/dat/acc}) & = & \{(\uparrow \text{concord case}) \in \{\text{nom,gen,dat,acc}\}\}
\end{array}
$$

They then define the description function *D* for the set of m-features as the union ($\cup$) of the result of applying *D* to each feature independently:

(47) Kaplan and Butt's (2002) description function *D* for a set of m-features:

$$D(\{d_1, d_2, ..., d_n\}) = D(d_1) \cup D(d_2) \cup ...\ D(d_n)$$

Andrews (2005) proposes a similar definition for his version of *D*, which he calls $\mathcal{F}$: each m-feature is placed in correspondence to a particular f-description, and the full f-description for a word form is obtained by collecting together the f-descriptions for each m-feature.[15]

This simple approach is adequate for many cases, but is not adequate for all of the analytical possibilities that may arise. We have seen the need to consider certain m-features in the context of other m-features, to specify an f-description in the absence of an m-feature, and to provide an analysis of complex m-features. We have also seen that some analyses may require reference to the Lexemic Index in the definition of *D*.

3.2. Definition of *D*

Recall that the *D*-mapping is a relation involving the following terms:

(48) General form of the description function *D*:

D <Lexemic Index, m-features, category, f-description$_M$ >

The *D*-mapping for the plural noun *dogs* given in (14) is repeated in (49). It relates the m-features {m-cat:noun, m-num:pl} to the c-structure category N and the f-description {(↑ index num)=pl}:

(49) *D* <dog1,
{m-cat:noun, m-num:pl},
N,
{(↑ index num)=pl}>

We propose the following definition of *D*:

[15] Andrews (2005) also extends his analysis to case stacking, discussed in Section 3.3.6.

(50) D <LI, m-features, category, f-description$_M$ > if and only if
D_{cat} <LI, m-features, category> and
D_{feats} <LI, m-features, ↑, f-description$_M$ >.

The c-structure category for a word form is specified by the D_{cat} mapping on the basis of the L(exemic) I(ndex) and the m-features, and the f-description$_M$ is determined by the mapping defined by D_{feats}. These mappings are defined on a language-by-language basis, though there is likely to be a great deal of commonality in their definitions across languages; this is an important topic of research on the interface between morphology and other components of the grammar.

A complicating factor in the definition of D_{feats} is that in some cases, in particular for complex m-features as described in Section 2.7 and for case stacking as described in Section 3.3.6, the D-mapping might require reference not to the f-structure ↑, but to other f-structures related to ↑. This means that we must explicitly specify the f-structure that is relevant for the definition of D_{feats} in the definition of D. For this reason, in the definition in (50), ↑ is specified as the third argument of D_{feats}.

3.2.1. D_{cat}: Defining the C-Structure Category

If we assume that English does not make use of complex c-structure categories, and furthermore that there are no "mixed" categories in English with differing morphological and syntactic categories, the definition of D_{cat} for English is:

(51) D_{cat} for English:

D_{cat} <LI, m-features, N> if and only if M-CAT:NOUN ∈ m-features.
D_{cat} <LI, m-features, V> if and only if M-CAT:VERB ∈ m-features.
D_{cat} <LI, m-features, A> if and only if M-CAT:ADJ ∈ m-features.
⋮

An additional m-feature may be necessary to specify the category as projecting or non-projecting (Chapter 3, Section 3.4).

For analyses assuming complex or mixed categories, additional m-features must be considered, as discussed in Section 2.2. We can restate the informal complex category rule in (29) in the current format:[16]

(52) D_{cat} <LI, m-features, V[prs.ptcp]>
if and only if {M-CAT:VERB, M-VTYPE:PRS.PTCP} ⊆ m-features.

An informal rule was given in (33a) for a complex category which is morphologically an adjective but syntactically a noun. That rule can be restated in the current format as in (53):

(53) D_{cat} <LI, m-features, N>
if and only if

[16]The subset relation ⊆ is defined and discussed in Chapter 6, Section 3.

{m-cat:adj, m-class:mixed-a-n} $\subseteq$ m-features, or
{m-cat:noun, m-class:regular} $\subseteq$ m-features.

According to the definition of D in (50), D_{cat} is required to apply in order to determine the c-structure category of a word form. It does not do any "feature accounting", however; whether the definition of D_{cat} appeals to one m-feature or more than one, all of the m-features are passed on to D_{feats} for determination of the f-description of the word form.

3.2.2. D_{feats}: F-Descriptions Corresponding to M-Features

The language-specific D_{feats} function determines the f-description of the f-structure f, obtained by considering each member of a set of m-features.

(54) Mapping m-features to f-descriptions, schematic definition:

D_{feats} $<\text{LI}, \{m_1, m_2, ...m_n\}, f, d_0 \cup d_1 \cup d_2 \cup ...d_n>$ if and only if
  $D_{default}$ $<\text{LI}, \{m_1, m_2, ...m_n\}, f, d_0>$ and
  D_{feat} $<\text{LI}, m_1, \{m_1, m_2, ...m_n\}, f, d_1>$ and
  D_{feat} $<\text{LI}, m_2, \{m_1, m_2, ...m_n\}, f, d_2>$ and
  $\vdots$
  D_{feat} $<\text{LI}, m_n, \{m_1, m_2, ...m_n\}, f, d_n>$.

In this definition, D_{feats} (with four arguments) relates a L(exemic) I(ndex), a set of m-features $\{m_1, m_2, ...m_n\}$, an f-structure f, and an f-description $d_1 \cup d_2 \cup ...d_n$ corresponding to those m-features. D_{feats} is defined in terms of two other functions: $D_{default}$ defines a set of default features d_0 which appear when certain m-features are absent, and the D_{feats} functions map individual m-features $m_1...m_n$ to f-descriptions $d_1...d_n$. That is, D_{feat} (with five arguments) specifies the mapping relation for a particular m-feature (for example, m_1) in the context of the LI, the complete set of m-features $\{m_1, m_2, ...m_n\}$, and a target f-structure f, mapping m_1 to the f-description d_1. According to this definition, then, each m-feature is considered in the context of all of the other m-features, and the appropriate f-description of the f-structure f is added to the full f-description. This requires a definition of $D_{default}$ for the language and of D_{feat} for each m-feature, as we now show.

The definition of D_{feats} is formulated so as to allow the D-mapping to specify constraints on any relevant f-structure. Usually, the relevant f-structure is $\uparrow$, as specified in (50); we discuss the D-mapping for complex m-features and case stacking in Sections 3.3.5 and 3.3.6, where the f-description may refer not to $\uparrow$, but to another f-structure related to $\uparrow$.

3.2.3. $D_{default}$: Privative M-Features and Defaults

As noted in Section 2.6 above, some but not all morphological theories assume the existence of privative features and feature defaults.[17] In a theoretical setting in which it is relevant, the $D_{default}$ function introduces an f-description in the absence of a particular m-feature or m-features. If we assume that the D-mapping function for a language includes some number n of default rules $D1_{default}...Dn_{default}$, the definition of $D_{default}$ is the following, where the default f-description (d_0 in the definition in 54) results from applying each of the n rules in turn:

(55) Default mappings $D_{default}$:

$$
\begin{aligned}
&D_{default} \text{ <LI, m-features, } f, d_1 \cup d_2 \cup ...d_n \text{ > if and only if}\\
&\quad D1_{default} \text{ <LI, m-features, } f, d_1 \text{ > and}\\
&\quad D2_{default} \text{ <LI, m-features, } f, d_2 \text{ > and}\\
&\quad \vdots\\
&\quad Dn_{default} \text{ <LI, m-features, } f, d_n \text{ >.}
\end{aligned}
$$

Notice that we have specified f as the relevant f-structure in the third argument position of the definition of $D_{default}$ and, in turn, of the individual default rules $D1_{default}...Dn_{default}$, to allow the D-mapping to impose constraints on the relevant f-structure, whether it is ↑ or another f-structure related to ↑. In most cases, the relevant f-structure is ↑, as specified in the definition in (50), but for complex m-features or case stacking another f-structure might be relevant, as we show in Sections 3.3.5 and 3.3.6.

Schematically, individual $D_{default}$ rules are stated as in (56); in this definition, the absence of the m-feature m_1 licenses the introduction of the f-description d_1 as a constraint on the f-structure f. In other words, if the privative feature m_1 is absent, d_1 appears in the default f-description of f; if m_1 is present, d_1 does not appear, and the empty f-description $\emptyset$ is introduced.

(56) Schematic default rule:

$$
\begin{aligned}
&D1_{default} \text{ <LI, m-features, } f, d_1 \text{ >}\\
&\quad \text{if and only if } m_1 \notin \text{ m-features (and possibly other conditions as well),}\\
&\text{otherwise } D1_{default} \text{ <LI, m-features, } f, \emptyset \text{ >.}
\end{aligned}
$$

Recall the example given in Section 2.6, in which we explore the possibility that plural nouns have a privative m-feature M-NUM:PL, while singular nouns have no M-NUM feature. Given these assumptions, the default rule introducing the constraint (f INDEX NUM)=SG in the absence of a plural m-feature is:[18]

---

[17] Privative features are not assumed in Paradigm Function Morphology (Stump 2001). When such theories of morphological realization are adopted, the $D_{default}$ function is not relevant, and the definition of $D_{default}$ which we provide in this section can be ignored.

[18] The negated set membership relation ∉ is defined and discussed in Chapter 6, Section 3.

(57) Example: Default mapping to a singular f-description for nouns without a plural m-feature

$D1_{default}$ <LI, m-features, f, {(f INDEX NUM)=SG}>

if and only if M-CAT:NOUN $\in$ m-features and M-NUM:PL $\notin$ m-features,

otherwise $D1_{default}$ <LI, m-features, f, $\emptyset$ >.

As with the D_{cat} rules, the $D_{default}$ rules are not involved in "feature accounting": once the default rules have applied to a set of m-features, that set is passed unchanged to the D_{feats} rule.

3.3. D_{feat}: Examples

3.3.1. Simple D-Mappings From M-Features to F-Descriptions

For a language with a very straightforward mapping between morphological and syntactic case, we have D-mappings such as the following, producing an f-description which the f-structure f must satisfy.[19]

(58) Example: Simple mapping from M-CASE to syntactic case

D_{feat} <LI, M-CASE:NOM, m-features, f, {(f CONCORD CASE)=NOM}>.
D_{feat} <LI, M-CASE:ACC, m-features, f, {(f CONCORD CASE)=ACC}>.
D_{feat} <LI, M-CASE:DAT, m-features, f, {(f CONCORD CASE)=DAT}>.
D_{feat} <LI, M-CASE:GEN, m-features, f, {(f CONCORD CASE)=GEN}>.

This rule does not require or disallow the presence of other m-features in defining the mapping between M-CASE and syntactic case; M-CASE:NOM maps to the f-description {(f CONCORD CASE)=NOM} for the f-structure f independent of the presence or absence of other m-features, and similarly for the other case possibilities.

If the mapping between morphological and syntactic case is completely straightforward, we can make use of a convenient abbreviation capturing the effects of each of the four separate D-rules in (58), borrowing the underscore notation for the argument of a parametrized template (Chapter 6, Section 7) to indicate that morphological case always matches syntactic case:

(59) Example: General mapping from any M-CASE to the corresponding f-structure CASE specification, abbreviating the set of rules in (58)

D_{feat} <LI, M-CASE:_CASE, m-features, f, {(f CONCORD CASE)=_CASE}>.

[19] As we have done so far, we use simple values like NOM and ACC as the value of the CASE attribute. Chapter 2, Section 5.7.5 provides a full discussion of the representation of the values of the CASE feature.

3.3.2. Context-Sensitive *D*-Mappings

The Latin deponent verb *loquor* 'I speak' is morphologically passive but syntactically active. According to the analysis of this pattern presented in Section 2.4, deponent verbs are associated with the m-feature m-class:deponent-voice, and in the presence of this feature, verbs with the m-feature m-voice:pass are associated with the f-structure constraint (↑ voice)=active. Non-deponent verbs have the m-feature m-class:regular, with a straightforward relation between morphological and syntactic voice. This pattern can be stated by means of the following set of D_{feat} rules, according to which a morphologically passive form is syntactically active if it has the features m-voice:pass and m-class:deponent-voice; if the form is morphologically regular, with the feature m-class:regular, morphological voice matches syntactic voice. The second rule uses the underscore notation introduced in Section 3.3.1, requiring matching values for the two features.

(60) Example: *D*-mapping dependent on the m-class m-feature

D_{feat} <LI, m-voice:pass, m-features, f, {(f voice)=active}>
  if and only if m-class:deponent-voice ∈ m-features.

D_{feat} <LI, m-voice:_voice, m-features, f, {(f voice)=_voice}>
  if and only if m-class:regular ∈ m-features.

3.3.3. Vacuous *D*-Mappings

Depending on the particular theory of the realization relation *R* and the mapping *D* from m-features to f-descriptions, certain m-features may be important in providing context for other *D*-mappings, but do not themselves map to an f-description. For these features, we must specify a mapping to the empty f-description.

(61) *D*-mapping to the empty f-description for an inert m-feature m_1

D_{feat} <LI, m_1, m-features, f, $\emptyset$ >.

For example, there may be no mapping to an f-description for the m-iclass feature representing inflectional class, though that feature may be important in providing the proper context for other *D*-mapping rules, as outlined in Section 2.4 and Section 3.3.2.

(62) Example: *D*-mapping to the empty f-description for the m-iclass:1 and m-iclass:2 m-features

D_{feat} <LI, m-iclass:1, m-features, f, $\emptyset$ >.

D_{feat} <LI, m-iclass:2, m-features, f, $\emptyset$ >.

To take another example, there may be no mapping to an f-description for the m-cat feature, though that feature is important in determining the c-structure category through the mapping D_{cat}. For cases like this, where all values for an m-feature map to the same f-description (here, the empty f-description ∅), we can make use of an abbreviatory convention according to which mentioning an m-feature without specifying its value is interpreted as specifying the same *D*-mapping for all possible values for the feature:

(63) Example: *D*-mapping to the empty f-description for the M-CAT m-feature with any value, using an abbreviatory convention mentioning only the M-CAT feature

$D_{feat} <\text{LI}, \text{M-CAT}, \text{m-features}, f, \emptyset >.$

The *D*-mapping rule in (63) maps the M-CAT attribute with any value to the empty f-description ∅.

3.3.4. *D*-Mapping Dependent on the LI

In Section 2.5, we saw that according to some analyses, lexical exceptions are analyzed by specifying a *D*-mapping which refers to the Lexemic Index. A schematic mapping of this type is:

(64) Schematic mapping for a lexical exception dependent on the Lexemic Index:

$D_{feat} <\text{LI}, m_1, \text{m-features}, f, d_1 >$
if and only if LI = l_1,

otherwise $D_{feat} <\text{LI}, m_1, \text{m-features}, f, d_2 >$.

For example, if we assume that the noun *measles* is specified as morphologically plural (with M-NUM:PL) but syntactically singular (with the value SG for the NUM feature at f-structure), it may be necessary for the *D*-mapping to take the Lexemic Index into account in the D-mapping for number. The rule in (65) states that the m-feature M-NUM:PL maps to a plural f-description in all cases except when the Lexemic Index is MEASLE1:

(65) Example: Mapping to syntactically singular f-description for the morphologically plural noun *measles*, and to plural f-description for all other nouns

$D_{feat} <\text{LI}, \text{M-NUM:PL}, \text{m-features}, f, \{(f\ \text{INDEX NUM})=\text{SG}\}>$
if and only if LI = MEASLE1,

otherwise $D_{feat} <\text{LI}, \text{M-NUM:PL}, \text{m-features}, f, \{(f\ \text{INDEX NUM})=\text{PL}\}>$.

3.3.5. *D*-Mapping for Complex M-Feature Specifications

As outlined in Section 2.7, some theories of the morphological realization relation *R* assume m-features with a complex structure, requiring an f-structure related to ↑ to be constrained. For example, Stump (2001) proposes the complex subject agreement m-feature in (66), encoding first person plural subject agreement:

(66) Example: Complex m-feature, Stump (2001)

AGR(SU):{PERS:1, NUM:PL}

Our goal is to map the m-feature in (66) to this f-description:

(67) Example: F-description corresponding to the m-feature in (66)

($\uparrow$ SUBJ INDEX PERS)=1
($\uparrow$ SUBJ INDEX NUM)=PL

To align more closely with the m-feature representations we have been assuming, we reformulate the complex m-feature in (66) in the following equivalent way:

(68) Variant representation of complex m-feature in (66):

M-AGR:<SU, {M-PERS:1, M-NUM:PL}>

In this reformulation, the value of the M-AGR m-feature is a pair in which the first argument SU is a morphological marker providing information about the syntactic role of the relevant f-structure for the complex feature specification, and the second argument is a set of m-features. To interpret this complex constraint, we require a rule which maps the morphological marker SU to the grammatical function SUBJ; given that mapping, we can identify the f-structure ($\uparrow$ SUBJ) which is the relevant f-structure for the set of constraints in the second argument.

We assume that the correspondence between the morphological marker SU and the grammatical function SUBJ is also specified as a part of the *D*-mapping, and thus that we have *D*-mapping rules of the following form:

(69) Example: Mapping between the morphological marker SU and the grammatical function SUBJ

D_{feat} <LI, SU, m-features, SUBJ, $\emptyset$ >

The rule in (69) states a correspondence between SU and the grammatical function SUBJ in the presence of a set of m-features, but does not contribute an f-description. We can make use of the mapping in (69) in the following *D*-mapping rule:

(70) Example: Mapping for a complex m-feature

D_{feat} <LI, M-AGR:<SU, {M-PERS:1, M-NUM:PL}>, m-features, f, d >
if D_{feat} <LI, SU, m-features, SUBJ, $\emptyset$ > and
and D_{feats} <LI, {M-PERS:1, M-NUM:PL}, (f SUBJ), d >.

In (70), the relevant f-structure is f, and the value of the complex M-ARG m-feature is a pair whose first argument is the morphological marker SU. The relation between SU and the grammatical function SUBJ is specified in the *D*-mapping rule defined in (69). The second argument is a set of m-features, {M-PERS:1, M-NUM:PL}, which map to the f-description constraining the relevant f-structure. The rule in (70) states that the set of m-features specified as the second member of the pair should be interpreted as constraining the D_{feats} mapping with respect to the SUBJ attribute in the f-structure f. That is, the relevant f-structure is (f SUBJ), and the D_{feats} mapping requires the f-description to hold of (f SUBJ).

This rule is a specific instance of the following general pattern:

(71) Mapping for complex m-features:

D_{feat} <LI, M-FEAT:<ATTR, M-FEATURES>, M, f, d >
  if D_{feat} <LI, ATTR, M-FEATURES, _GF, $\emptyset$ >
  and D_{feats} <LI, M-FEATURES, (f _GF), d >

According to this rule, the value of a complex m-feature is a pair in which the first argument specifies a morphological marker ATTR and the second argument is a set of m-features. The D_{feat} mapping for a complex feature with respect to f-structure f is defined as the D_{feats} mapping for the set of m-features, where the morphological marker ATTR maps to a grammatical function _GF, and the relevant f-structure for the constraints specified by the set of m-features is (f _GF).

3.3.6. Case Stacking and Constructive Case

In Chapter 6, Section 1.3, we discussed Nordlinger's (1998) theory of *constructive case*, according to which the case of an argument determines its syntactic role. Nordlinger (1998) also extends her theory to *case stacking*, in which an argument can bear more than one case feature determining the environment in which it must appear (see also Plank 1995). An example is the Martuthunira word form in (72) with three case endings, originally discussed by Dench (1995):

(72) *thara-ngka-marta-a*
pouch-LOC-PROP-ACC

The LOCative casemarking closest to the root *thara* 'pouch' marks the word as the head of a locative phrase ('in (its) pouch'). The PROPrietive and ACCusative casemarking further constrains the syntactic environment within which the phrase can appear: *thara-ngka* 'in its pouch' must modify a proprietive phrase ('with X in its pouch') which itself modifies an accusatively-marked phrase. According to Sadler and Nordlinger (2004), the f-structure for the form *thara-ngka-marta-a* is the one labeled p in (73), and it must appear in the f-structure environment shown:[20]

[20]The representation in (73) differs from the proposals of Nordlinger (1998) and Sadler and Nordlinger (2004) in using the standard set-valued attribute ADJ for adjuncts, rather than assuming different adjunct functions indexed by semantic role.

(73) Functional structure *p* for *thara-ngka-marta-a* and the environment in which it is required to appear (Sadler and Nordlinger 2004):

$$\left[\begin{array}{ll} \text{OBJ} & \left[\begin{array}{ll} \text{CONCORD} & \left[\begin{array}{ll} \text{CASE} & \boxed{\text{ACC}} \end{array}\right] \\ \text{ADJ} & \left\{ \left[\begin{array}{ll} \text{CONCORD} & \left[\begin{array}{ll} \text{CASE} & \boxed{\text{PROP}} \end{array}\right] \\ \text{ADJ} & \left\{ p\left[\begin{array}{ll} \text{PRED} & \text{‘POUCH’} \\ \text{CONCORD} & \left[\begin{array}{ll} \text{CASE} & \boxed{\text{LOC}} \end{array}\right] \end{array}\right] \right\} \end{array}\right] \right\} \end{array}\right] \end{array}\right]$$

Given these constraints, *thara-ngka-marta-a* can felicitously appear in a clause such as:

(74) *Ngayu nhawu-lha ngurnu tharta-a mirtily-marta-a*
I saw-PST that.ACC euro-ACC joey-PROP-ACC
thara-ngka-marta-a.
pouch-LOC-PROP-ACC
‘I saw the euro with a joey in (its) pouch.’[21] (Dench 1995)

The f-structure for (74) is given in (75), which meets the requirements given in (73) for the environment in which *thara-ngka-marta-a* must appear:

(75)
$$\left[\begin{array}{ll} \text{PRED} & \text{‘SEE}\langle\text{SUBJ,OBJ}\rangle\text{’} \\ \text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{‘PRO’} \\ \text{INDEX} & \left[\begin{array}{ll} \text{PERS} & 1 \\ \text{NUM} & \text{SG} \end{array}\right] \end{array}\right] \\ \text{OBJ} & \left[\begin{array}{ll} \text{PRED} & \text{‘EURO’} \\ \text{CONCORD} & \left[\begin{array}{ll} \text{CASE} & \boxed{\text{ACC}} \end{array}\right] \\ \text{ADJ} & \left\{ \left[\begin{array}{ll} \text{PRED} & \text{‘JOEY’} \\ \text{CONCORD} & \left[\begin{array}{ll} \text{CASE} & \boxed{\text{PROP}} \end{array}\right] \\ \text{ADJ} & \left\{ p\left[\begin{array}{ll} \text{PRED} & \text{‘POUCH’} \\ \text{CONCORD} & \left[\begin{array}{ll} \text{CASE} & \boxed{\text{LOC}} \end{array}\right] \end{array}\right] \right\} \end{array}\right] \right\} \end{array}\right] \end{array}\right]$$

Sadler and Nordlinger (2004, 2006b) provide an analysis of case stacking within the theory of Paradigm Function Morphology (Stump 2001) which, like the complex m-features discussed in the previous section, appeals to the possibility of an

[21] A euro is a type of wallaroo, a kangaroo-like animal.

enriched structure for m-features: the order of the case features in case stacking is captured by allowing the value of a complex m-feature to consist of an embedded set of M-CASE m-features.

The table in (76), based on Sadler and Nordlinger (2004), states the relation between morphological case and the corresponding f-description. The *C* and *M* subscripts represent a distinction between Core cases, used adnominally and relationally, and Modal cases, encoding temporal contributions as well as complementizing and associating functions; for more discussion of this distinction, see Sadler and Nordlinger (2004, 2006b).

(76)

m-feature	f-description
Case_C:Loc	(↑ CONCORD CASE)=LOC, (ADJ ∈ ↑)
Case_C:Abl	(↑ CONCORD CASE)=ABL, (ADJ ∈ ↑)
Case_C:Prop	(↑ CONCORD CASE)=PROP, (ADJ ∈ ↑)
Case_C:Erg	(↑ CONCORD CASE)=ERG, (SUBJ ↑)
Case_C:Nom	(↑ CONCORD CASE)=NOM, (SUBJ ↑)
Case_M:Abl	(↑ TENSE)=PST

In line with the theory of constructive case originally proposed by Nordlinger (1998) and described in Chapter 6, Section 1.3, Sadler and Nordlinger (2004, 2006b) propose the f-description for *thara-ngka-marta-a* given in (77), which describes the f-structure in (73):[22]

(77) (↑ PRED) = 'POUCH'
(↑ CASE) = LOC
((ADJ ∈ ↑) CONCORD CASE) = PROP
((ADJ ∈ ADJ ∈ ↑) CONCORD CASE) = ACC
(OBJ ADJ ∈ ADJ ∈ ↑)

Our goal, then, is to produce the f-description in (77) on the basis of the lexemic entry for *thara*, the m-entry for *thara-ngka-marta-a*, and a *D*-mapping given the m-entry.

We propose the following lexemic entry for *thara*:

(78) Lexemic entry for the root THARA1:

LE <{<M-ROOT:thara>}, {(↑ PRED)='POUCH'}, THARA1>

The f-description in this lexemic entry provides the first line of the f-description in (77).

Next, we require an m-entry for the word form *thara-ngka-marta-a* as provided by the realizational component *R* for Martuthunira. We adopt Sadler and Nordlinger's insight that the value of the M-CASE feature in case stacking is best represented as a recursively embedded set reflecting the order in which the case affixes appear in the word form:

[22] The f-description in (77) involves *inside-out functional uncertainty* (Chapter 6, Section 1.3) and uses the set membership symbol ∈ as an attribute (Chapter 6, Section 3.1).

(79) M-entry for *thara-ngka-marta-a*:

$\langle\textsc{thara}1$, thara-ngka-marta-a, /yɐ.ɻɐŋkɐmɐʈɐ:/,
$\{\ \textsc{m-case}{:}\{\textsc{m-case}_C{:}\textsc{loc},\ \{\textsc{m-case}_C{:}\textsc{prop},\ \{\textsc{m-case}_C{:}\textsc{acc}\}\}\}\ \}\rangle$

The task is now to extend the definition of *D* in such a way that this complex M-CASE specification maps to the following f-description, as desired:

(80)
$$\begin{aligned}&\textsc{m-case}{:}\{\textsc{m-case}_C{:}\textsc{loc},\ \{\textsc{m-case}_C{:}\textsc{prop},\ \{\textsc{m-case}_C{:}\textsc{acc}\}\}\} \overset{D}{\Rightarrow}\\ &\quad\{(\uparrow \textsc{case}) = \textsc{loc},\\ &\quad((\textsc{adj} \in \uparrow)\ \textsc{concord case}) = \textsc{prop},\\ &\quad((\textsc{adj} \in \textsc{adj} \in \uparrow)\ \textsc{concord case}) = \textsc{acc},\\ &\quad(\textsc{obj adj} \in \textsc{adj} \in \uparrow)\}\end{aligned}$$

Unlike the analysis of Sadler and Nordlinger (2004), we do not construct a tree as a part of the *D*-mapping; rather, we follow Andrews (2005) in proposing a recursive definition of *D* for set-valued features which produces the appropriate f-description.

It is helpful to reformulate the f-description in (80) to indicate which part of the M-CASE feature is responsible for which subpart of the f-description. Following Andrews (2005), we augment the f-description in (80) with separately specified existential constraints for each case specification. For example, in (81) we include the existential constraint $(\textsc{adj} \in \uparrow)$, which requires the f-structure $\uparrow$ to be a member of an adjunct set; this is part of the contribution of locative case-marking. This constraint is implied by the constraint $(\textsc{obj adj} \in \textsc{adj} \in \uparrow)$ in (80), which requires $\uparrow$ to be a member of an adjunct set which is itself in an adjunct set of an object. Including this simpler constraint and the other existential constraints in (81) produces a slightly expanded f-description which is equivalent to the one in (80), but where the commonalities in the different components of the f-description are more clearly revealed:

(81)
$$\begin{aligned}&\textsc{m-case}_C{:}\textsc{loc} && \left\{\begin{array}{l}(\uparrow \textsc{case}) = \textsc{loc}\\ (\textsc{adj} \in \uparrow)\end{array}\right.\\[1ex] &\{\textsc{m-case}_C{:}\textsc{prop}\} && \left\{\begin{array}{l}((\textsc{adj} \in \uparrow)\ \textsc{concord case}) = \textsc{prop}\\ (\textsc{adj} \in \textsc{adj} \in \uparrow)\end{array}\right.\\[1ex] &\{\{\textsc{m-case}_C{:}\textsc{acc}\}\} && \left\{\begin{array}{l}((\textsc{adj} \in \textsc{adj} \in \uparrow)\ \textsc{concord case}) = \textsc{acc}\\ (\textsc{obj adj} \in \textsc{adj} \in \uparrow)\end{array}\right.\end{aligned}$$

We can now give a slightly lengthier but more revealing restatement of the relevant f-description, closely following proposals by Andrews (2005) and using local names for f-structures (prefixed by a percent sign %: see Chapter 6, Section 5):

(82)
$$\uparrow\ = \%f_0$$

$$\textsc{m-case}_C\textsc{:loc} \quad \left\{ \begin{array}{l} (\%f_0\ \textsc{concord case}) = \textsc{loc} \\ (\textsc{adj}\ \in \%f_0) = \%f_1 \\ \%f_1 \end{array} \right.$$

$$\{\textsc{m-case}_C\textsc{:prop}\} \quad \left\{ \begin{array}{l} (\%f_1\ \textsc{concord case}) = \textsc{prop} \\ (\textsc{adj}\ \in \%f_1) = \%f_2 \\ \%f_2 \end{array} \right.$$

$$\{\{\textsc{m-case}_C\textsc{:acc}\}\} \quad \left\{ \begin{array}{l} (\%f_2\ \textsc{concord case}) = \textsc{acc} \\ (\textsc{obj}\ \%f_2) = \%f_3 \\ \%f_3 \end{array} \right.$$

As this restatement makes clear, the f-structure which is constrained at each level of embedding is the one which is existentially quantified at the previous level of embedding. For the M-CASE feature, the following mappings are relevant. The definition in (83a) applies when the set value of the M-CASE attribute has two elements: a particular case value, and an embedded set containing further specification of the f-structure environment. The definition in (83b) applies when the set value of the M-CASE attribute has only one element. The definitions in (83c) specify the inside-out path _PATH required for each of the first two definitions.

(83) *D*-mapping for constructive M-CASE:

a. D_{feat} <LI, M-CASE:{_CASE1, _CASES}, M-FEATURES, f,
{(f CONCORD CASE)=_CASE1, (_PATH f) = f_1, f_1} $\cup$ d >
if D_{feat} <LI, M-CASE:_CASES, M-FEATURES, f_1, d >.

b. D_{feat} <LI, M-CASE:{_CASE1}, M-FEATURES, f,
{(f CONCORD CASE)=_CASE1, (_PATH f) = f_1, f_1} >.

c. If _CASE1 is LOC, ABL, or PROP, _PATH is ADJ $\in$.
If _CASE1 is ERG or NOM, _PATH is SUBJ.
If _CASE1 is ACC, _PATH is OBJ.

The definitions in (83a) and (83b) are relevant for all languages with case stacking. The definitions in (83c) are particular to Martuthunira, and are specified on a language-by-language basis.

4. FURTHER READING AND RELATED ISSUES

We have not provided a detailed history of LFG work on morphology and the interface between the morphological component and the rest of the grammar. The seminal Workshop on Morphology organized by Louisa Sadler and Andy Spencer at the LFG2000 conference marked the beginning of serious discussion of morphology in an LFG setting and the role of the morphological component in the LFG architecture; Sadler and Spencer (2000) present an overview of the workshop and provide pointers to some of the papers and presentations. Sadler and Spencer (2004) collects subsequent LFG-based work on morphology, and Sadler and Nordlinger (to appear) provide a very useful overview and comparison of work on morphology in the LFG and HPSG frameworks, including a discussion of morpheme-based approaches assuming annotated sublexical trees (Simpson 1991; Nordlinger 1998; Bresnan et al. 2016); see also Bonami and Crysmann (2016).

Morphological periphrasis has been a focus of interest since the foundational work of Sadler and Spencer (2001); Spencer (2013) provides a discussion of the relevant issues, and Biswas (2017) proposes a treatment of some of the central cases which combines LFG and Paradigm Function Morphology.

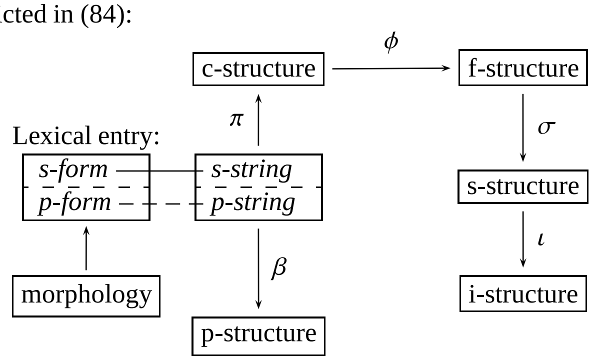
In the foregoing, we have assumed that f-structures and lexical entries are fully specified, and we have not appealed to any markedness or blocking principles that would lead us to choose the least marked form or the most specific compatible form in any given instance. This issue was discussed in detail by Andrews (1990b), who proposes the Morphological Blocking Principle, requiring that the most specific compatible lexical item must be chosen. Much LFG research discusses and relies on the Morphological Blocking Principle, and Bresnan (2001b) proposes a recasting of the principle in Optimality-Theoretic terms; Optimality-Theoretic LFG analyses are briefly discussed in Chapter 18, Section 1.3.

Part III

Phenomena

Throughout Part II, we have augmented our analysis of syntax presented in Part I with non-syntactic levels of representation: argument structure, semantic structure, information structure, prosodic structure, and the interface between morphology and the rest of the grammar. Our architectural assumptions have built on the foundational work of Kaplan (1987), Falk (2001b), Asudeh (2006, 2012), and Bresnan et al. (2016). To sum up, we assume the projection architecture depicted in (84):

(84)



With this basis in the formal theory of LFG, we are now ready to begin an exploration of the syntax and semantics of a variety of linguistic phenomena. In the next five chapters, we discuss the syntax and semantics of modification (Chapter 13); syntactic constraints on the anaphor-antecedent relation and the semantics of binding (Chapter 14); the syntax and semantics of functional and anaphoric control in constructions with raising and equi verbs (Chapter 15); the syntax of constituent and nonconstituent coordination, resource sharing at the syntax-semantics interface, and the syntax and semantics of noun phrase coordination (Chapter 16); and the syntax of long-distance dependencies and the semantics of relative clauses and constituent questions (Chapter 17).

13

MODIFICATION

This chapter explores issues in the syntax and semantics of modification. Since there is in principle no limit to the number of modifiers that a phrase can have, we represent modifiers at functional structure as members of a set of modifying adjuncts ADJ (Chapter 2, Section 4.4). Functional annotations on c-structure rules ensure that each modifier appears as a member of the adjunct set of the phrase it modifies.

In this chapter, we concentrate in particular on adjectival modification, since the syntax and semantics of adjectives is fairly complex and illustrates many of the issues of interest to us. Section 1 of this chapter provides an overview of the syntax of adjectival modification, Section 2 discusses three semantic classes of adjectives and how their meanings are represented, and Section 3 discusses adjectival modification at the syntax-semantics interface within the glue approach.

Defining the semantic contribution of a modifier brings up a set of tricky problems, as first noticed by Kasper (1997). In Section 4, we address these issues and show that they have a straightforward solution within our framework.

The chapter concludes with a brief examination of the syntax and semantics of adverbial modification: Section 5 discusses the syntax and semantics of manner adverbs like *skillfully*, as well as sentential adverbs like *clearly*.

1. SYNTAX OF ADJECTIVAL MODIFICATION

1.1. Modification at Functional Structure

As discussed in Chapter 2, Section 1.2, modifiers are different from arguments in that an f-structure can contain any number of modifiers, including none; the clause in (1a) has two modifiers, while (1b) shows that there cannot be multiple OBJ arguments in a clause.

(1) a. *The girl handed the baby a toy <u>on Tuesday</u> <u>in the morning</u>.*

b. **David saw <u>Tony</u> <u>Mr. Gilroy</u> <u>my next-door neighbor</u>.*

At f-structure, each modifier is a member of the ADJ set. In (2), the adjectival modifier *Swedish* is treated as a member of the ADJ set of modifiers of the noun *man*:

(2) *Swedish man*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{man}\text{'} \\ \textsc{adj} & \left\{ \begin{bmatrix} \textsc{pred} & \text{`}\textsc{Swedish}\text{'} \end{bmatrix} \right\} \end{bmatrix}$$

In phrases with more than one modifier, the f-structure for each modifier appears as a member of the ADJ set:

(3) *tall Swedish man*

$$\begin{bmatrix} \textsc{pred} & \text{`}\textsc{man}\text{'} \\ \textsc{adj} & \left\{ \begin{array}{l} \begin{bmatrix} \textsc{pred} & \text{`}\textsc{tall}\text{'} \end{bmatrix} \\ \\ \begin{bmatrix} \textsc{pred} & \text{`}\textsc{Swedish}\text{'} \end{bmatrix} \end{array} \right\} \end{bmatrix}$$

The lexical entries for the attributive adjectives *tall* and *Swedish* and the noun *man* contain at least the following syntactic information, including specification of syntactic form (FM), phrase structure category (the result of applying the labeling function λ to the terminal c-structure node $\pi(\bullet)$), and the value of the PRED feature:[1]

(4) Lexical entries for *tall*, *Swedish*, and *man*:

a. *tall* $\widehat{\text{A}}$ $(\uparrow \textsc{pred}) = \text{`}\textsc{tall}\text{'}$

b. *Swedish* $\widehat{\text{A}}$ $(\uparrow \textsc{pred}) = \text{`}\textsc{Swedish}\text{'}$

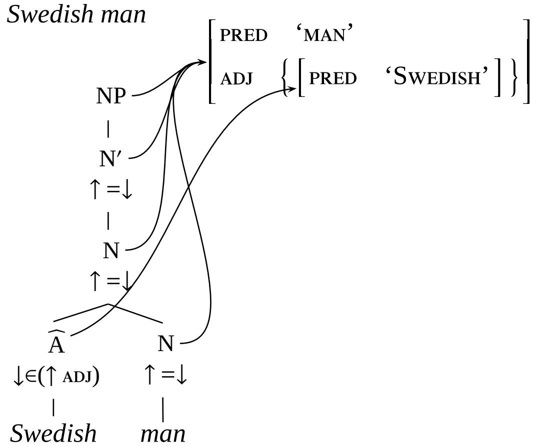
c. *man* N $(\uparrow \textsc{pred}) = \text{`}\textsc{man}\text{'}$

[1] Since we do not provide morphological or prosodic analyses in Part III, we revert to the standard format for lexical entries introduced in Chapter 5, Section 3.2, rather than the abbreviated lexical entry format introduced in Chapter 12, example (2). We also omit the p-form specification in each entry. For a discussion of fully-specified lexical entries, including the p-form, see Chapter 11, Section 4.1.

1.2. Constituent Structure Constraints

At constituent structure, modifiers are often adjoined to the phrases they modify (Chapter 3, Section 3.4). The c-structure and f-structure for the English noun phrase *Swedish man* is shown in (5). The prenominal modifier *Swedish* is a non-projecting adjective $\widehat{\mathrm{A}}$, adjoined at the N level (see Chapter 3, Section 3.4, Toivonen 2003, Arnold and Sadler 2013, and references cited there):[2]

(5) *Swedish man*



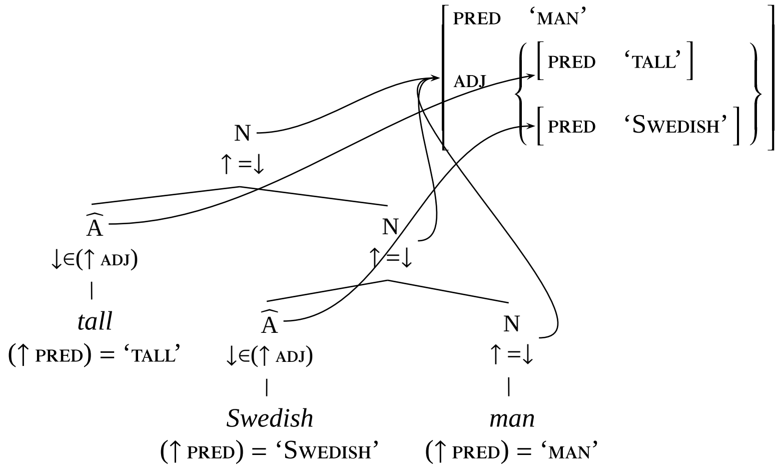
We propose the following adjunction rule for prenominal adjective modifiers in English:

(6) $$\mathrm{N} \longrightarrow \underset{\downarrow \in (\uparrow \textsc{adj})}{\widehat{\mathrm{A}}} \quad \underset{\uparrow = \downarrow}{\mathrm{N}}$$

This rule allows non-projecting adjectives to be adjoined at the N level. At f-structure, each adjective is a member of the adjunct set ADJ. In (7), two adjectives have been adjoined:

[2]For discussion of postnominal AP modifiers, see Arnold and Sadler (2013).

(7) *tall Swedish man*



2. SEMANTIC CLASSES OF ADJECTIVES

Foundational work on the semantics of adjectives was carried out by Montague (1970a) and Kamp (1975), who focused primarily on the three types of adjectives to be examined in this section. Their basic view of the semantics of adjectival modification has been widely adopted.

As discussed in Chapter 8, Section 8.2, we define a proper noun's meaning thus:

(8) Meaning of *man*:

$\lambda x.\mathit{man}(x)$

This meaning is of type $\langle e \rightarrow t\rangle$. It picks out the set of men – that is, the set of entities x for whom the proposition $\mathit{man}(x)$ is true. When a meaning like the one in (8) is modified, the result is a meaning which is of the same type but which reflects a modified meaning rather than the original unmodified meaning. In this section, we describe how noun meanings are modified in different ways by different semantic classes of adjectives.

2.1. Intersective Adjectives

The meaning of *Swedish man* can be represented as in (9), in which the conjunction operator $\wedge$ conjoins the two expressions $\mathit{Swedish}(x)$ and $\mathit{man}(x)$:

(9) Meaning of *Swedish man*:

$\lambda x.\mathit{Swedish}(x) \wedge \mathit{man}(x)$

The type of this meaning is $\langle e \rightarrow t \rangle$, just like the unmodified meaning *man*; the difference in meaning is that this expression picks out the set of individuals x that satisfy both the predicate $\mathit{Swedish}(x)$ and the predicate $\mathit{man}(x)$ — the individuals that are both Swedish and men. Adjectives like *Swedish* are called *intersective*, since the individuals who are Swedish men are those that are in the intersection[3] of the set of individuals that are Swedish with the set of individuals that are men. As Partee (1995) points out, for intersective adjectives the conclusion in (10c) follows from the premises in (10a) and (10b):

(10) a. *David is a Swedish man.* [David is in the intersection of the set of Swedish individuals and the set of men.]

b. *David is a football player.* [David is in the set of football players.]

c. *Therefore, David is a Swedish football player.* [David is in the intersection of the set of Swedish individuals and the set of football players; that is, David is both Swedish and a football player.]

2.2. Subsective Adjectives

Not all adjectives are intersective. For example, Partee (1995) notes that we cannot perform the same kind of reasoning as in (10) with an adjective like *big*:

(11) a. *Mortimer is a big mouse.*

b. *Mortimer is an animal.*

c. [does not follow:] *Therefore, Mortimer is a big animal.*

Such adjectives are called *subsective*: the set of big mice is a subset of the set of mice, but a *big mouse* is not in the intersection of the set of things that are big in general with the set of mice. Indeed, it is not clear whether it makes sense to talk about the set of things that are 'big in general'; to the extent that it does, the set of things that are 'big in general' would contain solar systems and galaxies, and possibly mountains and oceans, but certainly not mice.

There are several kinds of subsective adjectives.[4] One type is *gradable* adjectives like *big* or *tall*, which, as noted by Montague (1970a), Kamp (1975), Siegel (1976), Kennedy (1997), and many others, must be interpreted relative to some relevant standard. For example, a particular mouse might count as a *big mouse*, even though the same mouse is probably not a big animal or even a big

[3]The intersection of two sets contains all of the members that the two sets have in common: see Chapter 6, Section 3.

[4]One well-studied type of subsective adjective is exemplified by *beautiful* in one reading of *beautiful dancer*, which can refer either to an individual who is both beautiful and a dancer, or (in the non-intersective, subsective reading) to an individual who dances beautifully (Siegel 1976). Larson (1998) proposes to treat this ambiguity by allowing *beautiful* to specify either the individual variable for *dancer*, giving rise to the meaning 'beautiful and a dancer', or the event variable associated with the dancing event, giving rise to the meaning 'dance beautifully'. Though we will not provide an explicit analysis of these examples here, such an analysis can be easily formulated in a glue setting by adopting a semantic representation including event variables, as introduced in Chapter 8, Section 10.

rodent. Similarly, a seven-year-old boy can be correctly characterized as a *tall seven-year-old* even if he is not tall compared to an adult.

We propose the following simplified meaning for *big mouse* (see Kennedy 1997 for a full discussion of the semantics of gradability and comparison):

(12) Meaning of *big mouse*:

$\lambda x.\mathit{big}(x, \mathcal{P}) \wedge \mathit{mouse}(x)$

The argument $\mathcal{P}$ of *big* represents the contextually salient property that determines the relevant standard of measurement. If the property $\mathcal{P}$ of the individual is that it is a mouse, modification by the adjective *big* requires the individual to exceed some standard of size that is determined by reference to mousehood. In other words, in order to claim that something is big relative to the property of being a mouse, we need to know the range of sizes that are usual for mice.

In a neutral setting, the contextually relevant property is often the property denoted by the modified noun; for example, the contextually salient property $\mathcal{P}$ in an example like *big mouse* is generally resolved to the property of being a mouse. However, as pointed out by McConnell-Ginet (1979) and Pollard and Sag (1994), in certain contexts other interpretations are also possible. Pollard and Sag provide the following example:

(13) *The Linguistics Department has an important volleyball game coming up against the Philosophy Department. I see the Phils have recruited Julius to play with them, which means we are in real trouble unless we can find a* <u>good linguist</u> *to add to our team in time for the game.*

Here the property $\mathcal{P}$ relevant to the interpretation of the adjective *good* is being a volleyball player, since in this example *good linguist* means, more or less, *linguist who is good at playing volleyball*. Examples such as these show that the property $\mathcal{P}$ need not correspond to the property denoted by the modified noun, but can be determined contextually.

Of course, modified phrases can undergo further modification. The meaning of the doubly modified phrase *tall Swedish man* is:

(14) Meaning of *tall Swedish man*:

$\lambda x.\mathit{tall}(x, \mathcal{P}) \wedge \mathit{Swedish}(x) \wedge \mathit{man}(x)$

Even in a neutral context, the contextually relevant property $\mathcal{P}$ involved in the interpretation of the adjective *tall* can be resolved in more than one way. It can refer to someone who is Swedish, a man, and tall for a man, in which case the contextually relevant property $\mathcal{P}$ is the property of being a man. It can also refer to someone who is Swedish, a man, and tall for a Swedish man, in which case the contextually relevant property $\mathcal{P}$ is the property of being a Swedish man.

2.3. Nonsubsective Adjectives

Nonsubsective adjectives are a third class of modifying adjectives, including adjectives like *imaginary*, *former*, *fake*, and *alleged*. The statements in (15b) and (16b) do not follow from the statements in (15a) and (16a) respectively:

(15) a. *David is a former student.*

b. [does not follow:] *David is a student.*

(16) a. *This is a fake gun.*

b. [does not follow:] *This is a gun.*

These adjectives, studied by Kamp (1975) and in more detail by Siegel (1976), are different from those discussed in the previous section in an important way: a *Swedish man* is a man, and a *big mouse* is a mouse, but a *fake gun* is not a gun; instead, it may actually be a toy or a piece of soap. Thus, the meaning of a phrase with a nonsubsective adjective depends on the meaning of the unmodified phrase, but the resulting property may hold of an individual even if the unmodified meaning does not. In other words, the set of individuals referred to by the modified noun is in general not a subset of the set of individuals referred to by the unmodified noun: this is why these adjectives are called nonsubsective.

Like other adjectives, a nonsubsective adjective operates on the description it modifies and produces a new description of the same type.[5]

(17) Meaning of *former student*:

$\lambda x.\mathit{former}(x, \mathit{student})$

A former student is one who at some previous time was a student, but who is no longer a student; the meaning of *student* is important in understanding the meaning of *former student*, but the individuals represented by x in the meaning given in (17) for *former student* are not required to be students. Thus, *former* in (17) denotes a relation between the property of being a student and some individual who formerly had that property. Similarly, a fake gun is an entity that is not a gun, but which has some properties in common (for example, appearance) with entities that are actually guns; again, although a fake gun is not a gun, the meaning of *gun* is important in determining the meaning of *fake gun*.

[5] Partee (2010) argues that adjectives that have traditionally been classified as nonsubsective are actually subsective, inducing coercion of the meaning of the modified noun. In Partee's example (a), for instance, the denotation of the first underlined occurrence of *fur* is expanded to include not only fur, but material resembling fur in some respect, while the second underlined occurrence of *fur* has its normal meaning, and refers only to actual fur:

(a) *I don't care whether that fur is fake <u>fur</u> or real <u>fur</u>.*

Adopting this view and eliminating the category of nonsubsective adjectives would allow a simplification of the compositional semantic treatment that we present in this chapter; for the sake of clarity of analysis and consistency with much of the literature on adjective semantics, we maintain the traditional three-way distinction between intersective, (non-intersective) subsective, and nonsubsective adjectives in our discussion.

(18) Meaning of *fake gun*:

$$\lambda x.\mathit{fake}(x, \mathit{gun})$$

Importantly, the resulting meaning still has the same type as the unmodified noun; nonsubsective adjectives, like intersective adjectives and gradable adjectives, turn an unmodified $\langle e \rightarrow t \rangle$ meaning into a modified $\langle e \rightarrow t \rangle$ meaning.[6] In fact, the type of an unmodified meaning is always the same as the type of the modified meaning, and this is important in our analysis of modification and meaning composition.

3. MODIFIERS AND SEMANTIC COMPOSITION

As Montague (1970a) and Kamp (1975) point out, adjectival modifiers are functions that take a property of type $\langle e \rightarrow t \rangle$ (such as the property of being a man) and produce a new property (such as the property of being a Swedish man). This intuition is reflected in the glue semantic premises contributed by modifiers.

3.1. Adjectival Modification

As shown in Chapter 8, Section 8.2, a common noun like *man* is associated with the syntactic and semantic structures and meaning constructor given in (19), where the semantic structures v and r are the values of the attributes VAR and RESTR in the semantic structure m_σ.

(19) F-structure, s-structure, and meaning constructor for *man*:

$$m\begin{bmatrix}\text{PRED} & \text{`MAN'}\end{bmatrix} \dashrightarrow m_\sigma\begin{bmatrix}\text{VAR} & v[\;] \\ \text{RESTR} & r[\;]\end{bmatrix}$$

$$\lambda x.\mathit{man}(x) : v \multimap r$$

A modified noun like *Swedish man* is associated with a meaning constructor whose right-hand (glue) side is exactly the same as the meaning constructor for *man*, but whose left-hand (meaning) side is associated with a modified meaning rather than an unmodified one.

(20) F-structure, s-structure, and meaning constructor for *Swedish man*:

$$m\begin{bmatrix}\text{PRED} & \text{`MAN'} \\ \text{ADJ} & \left\{\begin{bmatrix}\text{PRED} & \text{`SWEDISH'}\end{bmatrix}\right\}\end{bmatrix} \dashrightarrow m_\sigma\begin{bmatrix}\text{VAR} & v[\;] \\ \text{RESTR} & r[\;]\end{bmatrix}$$

$$\lambda x.\mathit{Swedish}(x) \wedge \mathit{man}(x) : v \multimap r$$

[6] We ignore the role of intensionality in the interpretation of subsective and nonsubsective adjectives; for discussion of the semantics of adjectives and intensionality, see Kamp and Partee (1995) and Partee (2010).

In this section, we show how a meaning constructor like the one in (20) is derived from the meaning constructors for *Swedish* and *man*.

Augmented lexical entries for *Swedish* and *man*, including meaning constructors, are as follows.[7]

(21) Lexical entries for *man* and *Swedish*, including meaning constructors:

a. *man* N $(\uparrow \text{PRED}) = \text{`MAN'}$
$\lambda x.man(x) : (\uparrow_\sigma \text{VAR}) \multimap (\uparrow_\sigma \text{RESTR})$

b. *Swedish* $\widehat{\text{A}}$ $(\uparrow \text{PRED}) = \text{`SWEDISH'}$
$\lambda P.\lambda x.Swedish(x) \wedge P(x)$:
$[((\text{ADJ} \in \uparrow)_\sigma \text{ VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma \text{ RESTR})] \multimap$
$[((\text{ADJ} \in \uparrow)_\sigma \text{ VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma \text{ RESTR})]$

The meaning constructor for *man* is familiar from our discussion of common nouns in Chapter 8, Section 8.2. The meaning constructor for *Swedish* uses *inside-out functional uncertainty* (Chapter 6, Section 1.3) to refer to the semantic structure of the phrase it modifies. The expression $(\text{ADJ} \in \uparrow)$ refers to the f-structure in which $\uparrow$ appears as a member of the modifier set;[8] in (20), this f-structure is labeled *m*. The expression $(\text{ADJ} \in \uparrow)_\sigma$ refers to the semantic structure corresponding to that f-structure (so m_σ in 20), and the expression $((\text{ADJ} \in \uparrow)_\sigma \text{ VAR})$ refers to the value of the attribute VAR in that semantic structure, labeled *v* in (20). Similarly, the expression $((\text{ADJ} \in \uparrow)_\sigma \text{ RESTR})$ refers to the value of the RESTR attribute, labeled *r* in (20).

Instantiating the meaning constructors in (21) according to the labels on the structures displayed in (20), we have the following instantiated meaning constructors for *Swedish* and *man*.

(22) Meaning constructor premises for *Swedish man*:

[man] $\lambda x.man(x) \;:\; v \multimap r$

[Swedish] $\lambda P.\lambda x.Swedish(x) \wedge P(x) \;:\; [v \multimap r] \multimap [v \multimap r]$

The right-hand side of the meaning constructor for *Swedish* illustrates the characteristic glue contribution of a modifier: it requires a resource of the form $v \multimap r$ as its argument and produces a resource of exactly the same form. The general form for modifiers is given in (23), where $\mathcal{M}$ is the meaning of the modifier and S is the glue contribution of the phrase it modifies.

(23) General form of modifier meaning constructor:

$\mathcal{M} : S \multimap S$

Modifiers consume a meaning resource S and produce an identical new meaning resource S for the phrases they modify.

[7] In Section 4, we will refine this analysis in our discussion of recursive modification (modification of modifiers).

[8] The use of the set membership symbol $\in$ as an attribute is discussed in Chapter 6, Section 3.1.

Given the premises **[Swedish]** and **[man]**, we can perform a deduction that produces the meaning constructor for *Swedish man* given in (20).

(24) $\lambda x.\mathit{man}(x) : v \multimap r$

This is the meaning constructor **[man]**. It associates the meaning $\lambda x.\mathit{man}(x)$ with the implicational contribution $v \multimap r$.

$\lambda P.\lambda x.\mathit{Swedish}(x) \wedge P(x) : [v \multimap r] \multimap [v \multimap r]$

This is the meaning constructor **[Swedish]**. On the glue side, it consumes the noun contribution $v \multimap r$ and produces a new modified meaning which is also associated with $v \multimap r$. On the meaning side, we apply the function $\lambda P.\lambda x.\mathit{Swedish}(x) \wedge P(x)$ to the unmodified meaning contributed by *man*, $\lambda x.\mathit{man}(x)$.

$\lambda x.\mathit{Swedish}(x) \wedge \mathit{man}(x) : v \multimap r$

We have produced a modified meaning $\lambda x.\mathit{Swedish}(x) \wedge \mathit{man}(x)$ associated with the implicational contribution $v \multimap r$. Note that the glue side of this meaning constructor is exactly the same as the glue side of the unmodified meaning constructor **[man]**; only the meaning is different.

We can also represent this deduction in abbreviated form, as shown in Chapter 8, using the labels in (22):

(25) **[Swedish]**, **[man]** $\vdash \lambda x.\mathit{Swedish}(x) \wedge \mathit{man}(x) : v \multimap r$

3.2. Gradable Adjectives

We have seen that gradable adjectives like *big* differ from intersective adjectives like *Swedish* in introducing a contextually salient property $\mathcal{P}$ in their interpretation:

(26) *big mouse*

$$m\begin{bmatrix} \text{PRED} & \text{‘MOUSE’} \\ \text{ADJ} & \left\{ \begin{bmatrix} \text{PRED} & \text{‘BIG’} \end{bmatrix} \right\} \end{bmatrix} \overset{m_\sigma}{\dashrightarrow} \begin{bmatrix} \text{VAR} & v[\ ] \\ \text{RESTR} & r[\ ] \end{bmatrix}$$

$\lambda x.\mathit{big}(x, \mathcal{P}) \wedge \mathit{mouse}(x) : v \multimap r$

The meaning contribution of *big mouse* given in (26) refers to a mouse that exceeds the size of individuals that are described by the contextually determined property $\mathcal{P}$. Since the property $\mathcal{P}$ is determined by contextual factors, not by semantic composition on the basis of syntactic relations, we will not specify a means for determining $\mathcal{P}$ but instead will leave it uninstantiated.

Although the meaning contribution of a gradable adjective like *big* is not the same as that of an intersective adjective like *Swedish*, the right-hand sides of the two meaning constructors are the same, since the two kinds of adjective play a similar role in meaning assembly. The lexical entry for *big* in (27) again includes a somewhat simplified meaning constructor, pending our discussion of recursive modification in Section 4.

(27) Lexical entry for *big*:

$$\begin{array}{lll} \textit{big} & \widehat{\mathrm{A}} & (\uparrow \textsc{pred}) = \text{`}\textsc{big}\text{'} \\ & & \lambda R.\lambda x.\mathit{big}(x, \mathcal{P}) \wedge R(x): \\ & & \quad [((\textsc{adj} \in \uparrow)_\sigma\ \textsc{var}) \multimap ((\textsc{adj} \in \uparrow)_\sigma\ \textsc{restr})] \multimap \\ & & \qquad [((\textsc{adj} \in \uparrow)_\sigma\ \textsc{var}) \multimap ((\textsc{adj} \in \uparrow)_\sigma\ \textsc{restr})] \end{array}$$

Like the entry for *Swedish* given in (21), this entry uses inside-out functional uncertainty to refer to the f-structure of the phrase it modifies. The lexical entry for *mouse* is exactly analogous to the one for *man*, and will not be displayed.

Instantiating the lexical entries for *big* and *mouse* according to the labels in (26), we obtain the following instantiated meaning constructors.

(28) Meaning constructor premises for *big mouse*:

$$\begin{array}{ll} \textbf{[mouse]} & \lambda x.\mathit{mouse}(x)\ :\ v \multimap r \\ \textbf{[big]} & \lambda R.\lambda x.\mathit{big}(x, \mathcal{P}) \wedge R(x)\ :\ [v \multimap r] \multimap [v \multimap r] \end{array}$$

The meaning constructor for *big* requires a meaning resource of the form $v \multimap r$, and *mouse* provides such a resource. The resulting meaning is obtained by applying the expression $\lambda R.\lambda x.\mathit{big}(x, \mathcal{P}) \wedge R(x)$ to its argument $\lambda x.\mathit{mouse}(x)$. The result is as desired — from the meaning constructors labeled **[big]** and **[mouse]** in (28), we derive the following meaning constructor for *big mouse*:

(29) $\textbf{[big]}, \textbf{[mouse]} \vdash \lambda x.\mathit{big}(x, \mathcal{P}) \wedge \mathit{mouse}(x) : v \multimap r$

3.3. Nonsubsective Adjectives

The syntactic and semantic structures and meaning constructor for the phrase *former student* are:

(30) *former student*

$$s\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{student}\text{'} \\ \textsc{adj} & \left\{ \left[ \textsc{pred} \quad \text{`}\textsc{former}\text{'} \right] \right\} \end{array}\right] \dashrightarrow s_\sigma \left[\begin{array}{ll} \textsc{var} & v[\ ] \\ \textsc{restr} & r[\ ] \end{array}\right]$$

$\lambda x.\mathit{former}(x, \mathit{student}) : v \multimap r$

The (simplified) lexical entry of *former* is as follows.

(31) Lexical entry for *former*:

$$\begin{array}{lll} \textit{former} & \widehat{\mathrm{A}} & (\uparrow \textsc{pred}) = \text{`}\textsc{former}\text{'} \\ & & \lambda P.\lambda x.\mathit{former}(x,P): \\ & & \quad [((\textsc{adj} \in \uparrow)_\sigma\ \textsc{var}) \multimap ((\textsc{adj} \in \uparrow)_\sigma\ \textsc{restr})] \multimap \\ & & \qquad [((\textsc{adj} \in \uparrow)_\sigma\ \textsc{var}) \multimap ((\textsc{adj} \in \uparrow)_\sigma\ \textsc{restr})] \end{array}$$

As shown earlier, the meaning contribution of an nonsubsective adjective like *former* is different from *Swedish* and *big*. Nevertheless, it contributes a meaning resource of the same form: it consumes a resource corresponding to the phrase it modifies and produces a new resource of the same form. The instantiated meaning constructors for *former* and *student* are as follows.

(32) Meaning constructor premises for *former student*:

$$\begin{array}{lr} \textbf{[student]} & \lambda x.\mathit{student}(x) \ : \ v \multimap r \\ \textbf{[former]} & \lambda P.\lambda x.\mathit{former}(x,P) \ : \ [v \multimap r] \multimap [v \multimap r] \end{array}$$

As desired, these meaning constructors combine to produce the meaning constructor for *former student* given in (30):

(33) $\textbf{[former]}, \textbf{[student]} \vdash \ \lambda x.\mathit{former}(x, \mathit{student}) : v \multimap r$

Although each type of modifier makes a different kind of contribution to meaning, their roles in meaning assembly are similar; this is reflected in the meaning resources on the right-hand sides of the meaning constructors for the modifying adjectives we have examined.

4. RECURSIVE MODIFICATION

In the previous section, we assumed that the function of a modifier is to specify the result that is obtained when it combines with the phrase it modifies — in other words, that the meaning of an adjective is defined in terms of its effect on the element that it modifies. This common assumption is challenged in an important paper by Kasper (1997), who discusses evidence from *recursive modification*: cases in which a modifier is itself modified. In this section, we review Kasper's observations and show how they are accounted for in the glue approach.

Consider a modifier like *Swedish*, which we assumed in the previous section to have a meaning constructor like this:

(34) *Swedish*

$$\left[\textsc{adj}\quad \left\{ \left[\textsc{pred}\quad \text{`}\textsc{Swedish}\text{'}\right] \right\}\right] \dashrightarrow \begin{bmatrix} \textsc{var} & v[\ ] \\ \textsc{restr} & r[\ ] \end{bmatrix}$$

$$\lambda P.\lambda x.\mathit{Swedish}(x) \wedge P(x) : [v \multimap r] \multimap [v \multimap r]$$

The meaning constructor for *Swedish* given in (34) provides information about how to determine the meaning of the phrase it modifies. It does not provide a representation for the meaning of *Swedish* independent of its modifying effect; instead, it represents only the conjunctive meaning that results from combining *Swedish* with the phrase it modifies.

Kasper (1997) shows that this view is inadequate by considering examples like the following:

(35) *obviously Swedish*

$$\begin{bmatrix} \text{ADJ} & \left\{ \begin{bmatrix} \text{PRED} & \text{`SWEDISH'} \\ \text{ADJ} & \left\{ \begin{bmatrix} \text{PRED} & \text{`OBVIOUSLY'} \end{bmatrix} \right\} \end{bmatrix} \right\} \end{bmatrix} \dashrightarrow \begin{bmatrix} \text{VAR} & v[\ ] \\ \text{RESTR} & r[\ ] \end{bmatrix}$$

$$\lambda P.\lambda x.\mathsf{obviously}(\mathsf{Swedish}(x)) \wedge P(x) : [v \multimap r] \multimap [v \multimap r]$$

In this example, the modifier *Swedish* is itself modified by the adverb *obviously*. The effect of modification by *obviously* is to modify the proposition that x is Swedish, $\mathsf{Swedish}(x)$, to produce a new proposition $\mathsf{obviously}(\mathsf{Swedish}(x))$. However, the proposition $\mathsf{Swedish}(x)$ is not by itself associated with the meaning of the adjective *Swedish*, and in fact there is no clear way to disentangle the meaning $\mathsf{Swedish}(x)$ from the rest of the meaning contribution for *Swedish* in (34).

For a meaning like $\mathsf{Swedish}(x)$ to be available, we require an independent, modifiable characterization of the intrinsic meaning of *Swedish*, which we assume to be the $\langle e \rightarrow t \rangle$ type meaning $\lambda x.\mathsf{Swedish}(x)$. We also require a theory of how this meaning combines with the meaning of the modified noun. Kasper (1997) provides an analysis of examples like (35) within the framework of Head-Driven Phrase Structure Grammar; though it is stated in different formal terms, our analysis has a clear basis in Kasper's proposal.

4.1. Meaning Constructors for Modifiers

In light of these observations, we must refine our assumptions about the meaning contributions of adjectives. We first note that adjectives like *Swedish* can also be used predicatively:[9]

(36) *Sven is Swedish.*

For this case as well, the appropriate meaning for *Swedish* is $\lambda x.\mathsf{Swedish}(x)$, the intrinsic, modifiable meaning of the adjective.

There is an independent difference in English between adjectives used predicatively, as in (36), and adjectives used as prenominal attributive modifiers: as shown in (5), English prenominal attributive adjectives are non-projecting ($\widehat{\text{A}}$) categories, while other, non-prenominal uses of adjectives involve the projecting category A as the head of AP. In fact, some English adjectives are only non-projecting, and can be used only prenominally (*late* with the meaning 'de-

[9]See Lowe 2013 for discussion of commonalities and differences in meaning constructors for attributive and predicative uses of adjectives, and Chapter 5, Section 4.5 for discussion of copular constructions.

ceased': *the late president*, but not *The president is late*, which means *The president is tardy* and not *The president is deceased*), while other adjectives do not have a non-projecting form and cannot be used prenominally (*afraid*: *The man is afraid*/*the man afraid of spiders*, but not **the afraid man*). Thus, the different meaning contributions of attributive and predicative adjectives in English correlates with their status as projecting or non-projecting c-structure categories. Predicative adjectives are associated only with a type $\langle e \rightarrow t\rangle$ meaning, while attributive adjectives contribute an additional meaning constructor which combines the intrinsic adjective meaning with the meaning of the noun.

We now assume that the semantic structures of adjectives are internally structured, containing at least the attribute VAR. In (37), the f-structure f corresponds to a semantic structure f_σ with the attributes VAR and RESTR; as shown earlier, the values of these attributes are labeled v and r. The f-structure s of the adjective *Swedish* also has an attribute VAR, whose value we have labeled sv.

(37) *Swedish*

$$f\left[\text{ADJ}\quad \left\{ s\left[\text{PRED}\quad \text{`S{\scriptsize WEDISH}'}\right] \right\}\right] \qquad f_\sigma\left[\begin{array}{ll}\text{VAR} & v[\ ]\\ \text{RESTR} & r[\ ]\end{array}\right] \qquad s_\sigma\left[\text{VAR}\quad sv[\ ]\right]$$

The intrinsic meaning of the adjective *Swedish* is of type $\langle e \rightarrow t\rangle$. Since we assume that the basic types e and t are associated with semantic structures, we assign the type e to sv and the type t to s_σ. Thus, the meaning constructor in (38), which represents the core meaning of the word *Swedish*, is common to both projecting and non-projecting forms of the word.[10]

(38) Lexical entry for predicative adjective *Swedish*:

Swedish	A	$(\uparrow \text{PRED}) = \text{`S{\scriptsize WEDISH}'}$
		$\lambda x.\mathit{Swedish}(x) : (\uparrow_\sigma \text{VAR}) \multimap \uparrow_\sigma$

The meaning constructor in (39) for the non-projecting, attributive use of *Swedish* contains an additional meaning constructor, whose function is to provide instructions for combining the first meaning constructor with the noun it modifies.

(39) Lexical entry for non-projecting $\widehat{\text{A}}$ *Swedish* (final):

Swedish	$\widehat{\text{A}}$	$(\uparrow \text{PRED}) = \text{`S{\scriptsize WEDISH}'}$
		$\lambda x.\mathit{Swedish}(x) : (\uparrow_\sigma \text{VAR}) \multimap \uparrow_\sigma$
		$\lambda R.\lambda Q.\lambda x.R(x) \wedge Q(x) :$
		$[(\uparrow_\sigma \text{VAR}) \multimap \uparrow_\sigma] \multimap$
		$[[((\text{ADJ} \in \uparrow)_\sigma\ \text{VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma\ \text{RESTR})] \multimap$
		$[((\text{ADJ} \in \uparrow)_\sigma\ \text{VAR}) \multimap ((\text{ADJ} \in \uparrow)_\sigma\ \text{RESTR})]]$

[10]We assume that in an example like (36) the meaning constructor for the copula manages the relation between the value of the VAR attribute in the predicative adjective's semantic structure and the SUBJ of the copular construction.

Instantiating the two meaning constructors in (39) according to the labels given in (37) makes them much easier to read; we label the first meaning constructor in the lexical entry in (39) as **[Swedish-basic]** and the second as **[attr-adj]**:

(40) Meaning constructor premises for *Swedish*, used attributively:

$$\textbf{[Swedish-basic]} \quad \lambda x.\mathit{Swedish}(x) \;:\; [sv \multimap s_\sigma]$$

$$\textbf{[attr-adj]} \quad \lambda R.\lambda Q.\lambda x.R(x) \wedge Q(x) \;:\; [sv \multimap s_\sigma] \multimap [[v \multimap r] \multimap [v \multimap r]]$$

Importantly, we can deduce the meaning constructor for *Swedish* given in (22) from the two meaning constructors in (40). The meaning constructor **[Swedish-basic]** provides the semantic resource $sv \multimap s_\sigma$ that is required by **[attr-adj]**, and the resulting meaning is obtained by function application: the meaning contribution of **[attr-adj]**, $\lambda R.\lambda Q.\lambda x.R(x) \wedge Q(x)$, is applied to the meaning contribution of **[Swedish-basic]**, $\lambda x.\mathit{Swedish}(x)$.

(41) **[Swedish-basic]**, **[attr-adj]** $\vdash$ **[Swedish]**

Therefore, the two meaning constructors **[Swedish-basic]** and **[attr-adj]** can play exactly the same role in meaning assembly as the simple meaning constructor **[Swedish]** discussed in Section 3.1 of this chapter. In particular, from the premises **[Swedish-basic]**, **[attr-adj]**, and **[man]**, we correctly derive the meaning constructor for *Swedish man* given in (24):

(42) **[Swedish-basic]**, **[attr-adj]**, **[man]** $\vdash\ \lambda x.\mathit{Swedish}(x) \wedge \mathit{man}(x) : v \multimap r$

We treat other adjectival modifiers similarly: the basic meaning constructor for an adjective combines with a meaning constructor that reflects the function of the adjective, such as attributive modification, in the syntactic context of its use.

More generally, the example just presented illustrates that the simple and intuitive assumptions we make about meanings and how they combine often turn out to be largely correct, but may be in need of refinement to account for more complicated examples. In logical terms, the intuitively motivated meaning constructors often correspond to conclusions resulting from a deduction from a more refined set of basic meaning constructor premises. It is often easier to work with the simpler and more intuitive constructors; this is legitimate and theoretically sound, as long as it can be shown that they follow as a logical consequence from the more basic premises.

4.2. Modification of Modifiers

We now show the derivation of the meaning for *obviously Swedish man*, an example in which the modifier *Swedish* is itself modified. As above, we introduce a VAR attribute with value *ov* in the semantic structure o_σ corresponding to *obviously*:

(43) *[obviously Swedish] man*

$$f_\sigma\begin{bmatrix}\textsc{var} & v[\;]\\ \textsc{restr} & r[\;]\end{bmatrix}$$

$$f\begin{bmatrix}\textsc{pred} & \text{‘}\textsc{man}\text{’}\\ \textsc{adj} & \left\{ s\begin{bmatrix}\textsc{pred} & \text{‘}\textsc{Swedish}\text{’}\\ \textsc{adj} & \left\{ o\begin{bmatrix}\textsc{pred} & \text{‘}\textsc{obviously}\text{’}\end{bmatrix}\right\}\end{bmatrix}\right\}\end{bmatrix} \qquad s_\sigma\begin{bmatrix}\textsc{var} & sv[\;]\end{bmatrix}$$

$$o_\sigma\begin{bmatrix}\textsc{var} & ov[\;]\end{bmatrix}$$

$$\lambda x.\mathit{obviously}(\mathit{Swedish}(x)) \wedge \mathit{man}(x) : v \multimap r$$

Like adjectives, the adverb *obviously* can be modified:

(44) *[[quite obviously] Swedish] man*

As with the meaning constructors for *Swedish* given in (40), which we labeled **[Swedish-basic]** and **[attr-adj]**, the meaning contribution of *obviously* is twofold. The lexical entry for *obviously* is therefore:

(45) Lexical entry for *obviously*:

$$\begin{array}{lll} \textit{obviously} & \widehat{\text{Adv}} & (\uparrow \textsc{pred}) = \text{‘}\textsc{obviously}\text{’} \\ & & \lambda P.\mathit{obviously}(P) : [(\uparrow_\sigma \textsc{var}) \multimap \uparrow_\sigma] \\ & & \lambda Q.\lambda R.\lambda x.Q(R(x)) \ : \\ & & \quad [(\uparrow_\sigma \textsc{var}) \multimap \uparrow_\sigma] \multimap \\ & & \qquad [[((\textsc{adj} \in \uparrow)_\sigma \textsc{ var}) \multimap (\textsc{adj} \in \uparrow)_\sigma] \multimap \\ & & \qquad\quad [((\textsc{adj} \in \uparrow)_\sigma \textsc{ var}) \multimap (\textsc{adj} \in \uparrow)_\sigma]] \end{array}$$

Again, readability increases when the meaning constructors are instantiated according to the labels in (43).

(46) Meaning constructor premises for *obviously*:

[obviously-basic]	$\lambda P.\mathit{obviously}(P)$	$: [ov \multimap o_\sigma]$
[adv-adj]	$\lambda Q.\lambda R.\lambda x.Q(R(x))$	$: [ov \multimap o_\sigma] \multimap [[sv \multimap s_\sigma] \multimap [sv \multimap s_\sigma]]$

The meaning constructor labeled **[obviously-basic]** in (46) specifies the intrinsic, modifiable meaning of *obviously*, and the meaning constructor labeled **[adv-adj]** combines the intrinsic meaning of the adverb with the meaning of the adjective which it modifies.

The two meaning constructors **[obviously-basic]** and **[adv-adj]** combine to produce this meaning constructor:

(47) **[obviously]** $\lambda R.\lambda x.\mathit{obviously}(R(x)) : [sv \multimap s_\sigma] \multimap [sv \multimap s_\sigma]$

This meaning constructor consumes a meaning resource of the form $sv \multimap s_\sigma$, producing a new meaning resource of the same form but corresponding to a modified meaning.

We can now combine the meaning constructor **[obviously]** with the meaning constructor **[Swedish-basic]** in (40) to yield this meaning constructor:

(48) **[obviously-Swedish]** $\lambda x.\mathit{obviously}(\mathit{Swedish}(x)) : [sv \multimap s_\sigma]$

Notably, the right-hand side of this meaning constructor is the same as the right-hand side of the unmodified meaning constructor **[Swedish-basic]**, repeated here, and plays the same role in meaning composition.

(49) **[Swedish-basic]** $\lambda x.\mathit{Swedish}(x) : [sv \multimap s_\sigma]$

Next, we combine the meaning constructors **[obviously-Swedish]**, **[attr-adj]**, and **[man]** to produce the meaning constructor given in (43) for *obviously Swedish man*:

(50) **[obviously-Swedish]**, **[attr-adj]**, **[man]** $\vdash$

$$\lambda x.\mathit{obviously}(\mathit{Swedish}(x)) \wedge \mathit{man}(x) : v \multimap r$$

Thus, our refined theory of the semantic contribution of modifiers not only enables the clean and intuitive treatment of modification presented in Section 3 of this chapter, it also allows an analysis of recursive modification, which, as Kasper (1997) shows, has proven problematic in many other approaches.

4.3. Modified Gradable Adjectives

For modified gradable adjectives, the derivation proceeds in exactly the same way as for intersective adjectives. We propose the following lexical entry for the adjective *big*.

(51) Lexical entry for non-projecting $\widehat{\mathrm{A}}$ *big* (final):

big $\widehat{\mathrm{A}}$ $(\uparrow \textsc{pred}) = \text{‘}\textsc{big}\text{’}$

$$\lambda x.\mathit{big}(x, \mathcal{P}) : (\uparrow_\sigma \textsc{var}) \multimap \uparrow_\sigma$$

$$\begin{array}{l} \lambda R.\lambda Q.\lambda x.R(x) \wedge Q(x) : \\ \quad [(\uparrow_\sigma \textsc{var}) \multimap \uparrow_\sigma] \multimap \\ \qquad [[((\textsc{adj} \in \uparrow)_\sigma\ \textsc{var}) \multimap ((\textsc{adj} \in \uparrow)_\sigma\ \textsc{restr})] \multimap \\ \qquad\quad [((\textsc{adj} \in \uparrow)_\sigma\ \textsc{var}) \multimap ((\textsc{adj} \in \uparrow)_\sigma\ \textsc{restr})]] \end{array}$$

The f-structure and semantic structures for *obviously big mouse* are:

(52) *[[obviously big] mouse]*

$$m\left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{mouse}\text{’}\\ \textsc{adj} & \left\{ b\left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{big}\text{’}\\ \textsc{adj} & \left\{ o\left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{obviously}\text{’}\end{array}\right]\right\}\end{array}\right]\right\}\end{array}\right]$$

$$m_\sigma\left[\begin{array}{ll}\textsc{var} & v[\;]\\ \textsc{restr} & r[\;]\end{array}\right] \qquad b_\sigma\left[\begin{array}{ll}\textsc{var} & bv[\;]\end{array}\right] \qquad o_\sigma\left[\begin{array}{ll}\textsc{var} & ov[\;]\end{array}\right]$$

$$\lambda x.\textit{obviously}(\textit{big}(x,\mathcal{P})) \wedge \textit{mouse}(x) : v \multimap r$$

Again, instantiating the meaning constructor premises for *big* in (51) according to the labels in (52) makes them easier to read.

(53) Meaning constructor premises for *big*, used attributively:

[big-basic]	$\lambda x.\textit{big}(x,\mathcal{P}) \; : \; [bv \multimap b_\sigma]$
[attr-adj]	$\lambda R.\lambda Q.\lambda x.R(x) \wedge Q(x) \; : \; [bv \multimap b_\sigma] \multimap [[v \multimap r] \multimap [v \multimap r]]$

Notably, the meaning constructor labeled **[attr-adj]**, combining the intrinsic meaning $\lambda x.\textit{big}(x,\mathcal{P})$ of the adjective *big* with the noun meaning, is exactly the same as for the adjective *Swedish*. We assume the same meaning for *obviously* as in (47), where the two lexical premises in (46) are combined:

(54) **[obviously]** $\lambda R.\lambda x.\textit{obviously}(R(x)) : [bv \multimap b_\sigma] \multimap [bv \multimap b_\sigma]$

Given these premises, we can perform the following deduction:

(55) $\lambda R.\lambda x.\mathit{obviously}(R(x)) : [bv \multimap b_\sigma] \multimap [bv \multimap b_\sigma]$

This is the meaning constructor **[obviously]**. It associates the meaning $\lambda R.\lambda x.\mathit{obviously}(R(x))$ with the implicational contribution $[bv \multimap b_\sigma] \multimap [bv \multimap b_\sigma]$, consuming and then producing a resource of exactly the form contributed by **[big-basic]**.

$\lambda x.\mathit{big}(x, \mathcal{P}) : [bv \multimap b_\sigma]$

This is the meaning constructor contributing the intrinsic meaning of the adjective *big*, **[big-basic]**. On the glue side, it contributes an implication $bv \multimap b_\sigma$, and on the meaning side, it contributes the meaning $\lambda x.\mathit{big}(x, \mathcal{P})$, which holds of an individual x if x is big relative to some contextually-supplied standard $\mathcal{P}$.

$\lambda x.\mathit{obviously}(\mathit{big}(x, \mathcal{P})) : [bv \multimap b_\sigma]$

By combining the two previous meaning constructors **[obviously]** and **[big-basic]**, we have produced a modified meaning $\lambda x.\mathit{obviously}(\mathit{big}(x, \mathcal{P}))$ associated with the implicational contribution $bv \multimap b_\sigma$. Note that the glue side of this meaning constructor is exactly the same as the glue side of the unmodified meaning constructor **[big-basic]**.

$\lambda R.\lambda Q.\lambda x.R(x) \wedge Q(x) : [bv \multimap b_\sigma] \multimap [[v \multimap r] \multimap [v \multimap r]]$

This is the meaning constructor **[attr-adj]** (with the semantic structure variables instantiated as in 52), whose purpose is to combine the meaning in the previous step with the meaning constructor for the noun *mouse*.

$\lambda Q.\lambda x.\mathit{obviously}(\mathit{big}(x, \mathcal{P})) \wedge Q(x) : [v \multimap r] \multimap [v \multimap r]$

By combining the meaning constructors in the previous two steps, we have produced a meaning for the attributive modifier *obviously big*, which can now combine with the meaning constructor for *mouse*.

$\lambda x.\mathit{mouse}(x) : [v \multimap r]$

This is the meaning constructor **[mouse]**. On the glue side, it is of the appropriate form to be consumed by the modifier meaning constructor in the previous step.

$\lambda x.\mathit{obviously}(\mathit{big}(x, \mathcal{P})) \wedge \mathit{mouse}(x) : [v \multimap r]$

By combining the meaning constructors in the previous two steps, we have produced the desired meaning for *obviously big mouse*.

4.4. Modified Nonsubsective Adjectives

We now turn to the slightly more complex question of modification of a nonsubsective adjective such as *fake*. Syntactically, there is nothing exceptional about *fake*, and the f-structure and semantic structures for *obviously fake gun* are similar to the structures for *obviously Swedish man* and *obviously big mouse*:

(56) *[[obviously fake] gun]*

$$g\begin{bmatrix}\textsc{pred} & \text{`GUN'}\\ \textsc{adj} & \left\{ f\begin{bmatrix}\textsc{pred} & \text{`FAKE'}\\ \textsc{adj} & \left\{ o\begin{bmatrix}\textsc{pred} & \text{`OBVIOUSLY'}\end{bmatrix} \right\}\end{bmatrix} \right\}\end{bmatrix} \qquad g_\sigma\begin{bmatrix}\textsc{var} & v[\ ]\\ \textsc{restr} & r[\ ]\end{bmatrix} \quad f_\sigma\begin{bmatrix}\textsc{var} & fv[\ ]\end{bmatrix} \quad o_\sigma\begin{bmatrix}\textsc{var} & ov[\ ]\end{bmatrix}$$

$$\lambda x.\textit{obviously}(\textit{fake}(x, \textit{gun})) : v \multimap r$$

We assume the same meaning constructor for *obviously* as in the previous examples, but with the semantic structure variables instantiated as in (56):

(57) **[obviously]** $\lambda R.\lambda x.\textit{obviously}(R(x)) : [fv \multimap f_\sigma] \multimap [fv \multimap f_\sigma]$

However, as a nonsubsective adjective, *fake* makes a different meaning contribution from adjectives like *Swedish* and *big*. These differences are reflected in its lexical entry.

(58) Lexical entry for non-projecting $\widehat{\mathrm{A}}$ *fake* (final):

fake $\widehat{\mathrm{A}}$ $(\uparrow \textsc{pred}) = \text{`FAKE'}$

$\lambda P.\lambda x.\textit{fake}(x, P) : [((\textsc{adj} \in \uparrow)_\sigma\ \textsc{var}) \multimap ((\textsc{adj} \in \uparrow)_\sigma\ \textsc{restr})] \multimap [(\uparrow_\sigma\ \textsc{var}) \multimap \uparrow_\sigma]$

$\lambda Q.\lambda x.Q(x) : [(\uparrow_\sigma\ \textsc{var}) \multimap \uparrow_\sigma] \multimap [((\textsc{adj} \in \uparrow)_\sigma\ \textsc{var}) \multimap ((\textsc{adj} \in \uparrow)_\sigma\ \textsc{restr})]$

Instantiating the meaning constructors in (58) according to the semantic structure labels in (56), we have:

(59) Meaning constructor premises for *fake*:

[fake-basic] $\lambda P.\lambda x.\textit{fake}(x, P)\ :\ [v \multimap r] \multimap [fv \multimap f_\sigma]$

[nonsubsective-adj] $\lambda Q.\lambda x.Q(x)\ :\ [fv \multimap f_\sigma] \multimap [v \multimap r]$

The most important difference distinguishing *fake* from the other adjectives we have examined is that *fake* requires the meaning of the noun it modifies as an argument: on the glue side, it requires a meaning contribution of the form $[v \multimap r]$ to obtain an intrinsic meaning of the form $[fv \multimap f_\sigma]$, which is modifiable by *obviously*. Although these meaning constructors are quite different from those contributed by intersective and subsective adjectives, no special versions of the meaning constructors for adjectival modifiers like *obviously* or nouns like *man*, *mouse*, or *gun* are required. Given the meaning constructors for *obviously*, *fake*, and *gun*, we can perform the following deduction:

(60) $\lambda x.\mathit{gun}(x) : [v \multimap r]$

This is the meaning constructor **[gun]**.

$\lambda P.\lambda x.\mathit{fake}(x, P) : [v \multimap r] \multimap [fv \multimap f_\sigma]$

This is the meaning constructor **[fake-basic]**.

$\lambda x.\mathit{fake}(x, \mathit{gun}) : [fv \multimap f_\sigma]$

This meaning constructor results from combining **[fake-basic]** with **[gun]**.

$\lambda R.\lambda x.\mathit{obviously}(R(x)) : [fv \multimap f_\sigma] \multimap [fv \multimap f_\sigma]$

This is the meaning constructor **[obviously]**.

$\lambda x.\mathit{obviously}(\mathit{fake}(x, \mathit{gun})) : [fv \multimap f_\sigma]$

Combining **[obviously]** with the meaning constructor resulting from the step above it, we have produced a modified meaning associated with the implicational contribution $fv \multimap f_\sigma$.

$\lambda Q.\lambda x.Q(x) : [fv \multimap f_\sigma] \multimap [v \multimap r]$

This is the meaning constructor **[nonsubsective-adj]**. Its purpose is to assign a modified meaning to the phrase, incorporating the meaning of the noun *gun* and the meaning of *obviously fake*.

$\lambda x.\mathit{obviously}(\mathit{fake}(x, \mathit{gun})) : [v \multimap r]$

By combining the meaning constructors in the previous two steps, we have produced the desired meaning for *obviously fake gun*.

Again, the glue side of the meaning constructor for *obviously fake gun* is $[v \multimap r]$, exactly the same as the unmodified noun *gun*, as with all cases of modification.

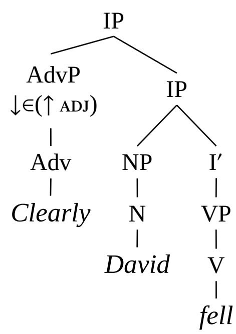
5. ADVERBIAL MODIFICATION

We now turn to an examination of the syntax and semantics of adverbial modification. The treatment provided here is brief, and we concentrate primarily on aspects of meaning composition; Butt et al. (1999, Chapter 7) provide more discussion of the syntax of adverbial modifiers from an LFG perspective.

5.1. Adverbs at C-Structure and F-Structure

In English, adverbs such as *clearly* and *skillfully* are adjoined to the phrases they modify. Like other modifiers, their f-structures appear as members of the set of ADJ modifiers. In (61), the sentential adverb *clearly* is adjoined to IP:

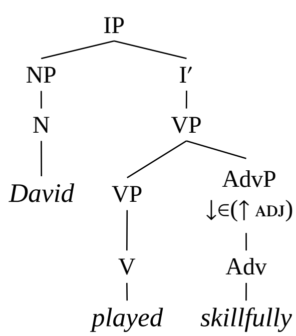
(61) *Clearly David fell.*



$$\begin{bmatrix} \text{PRED} & \text{`FALL}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`David'} \end{bmatrix} \\ \text{ADJ} & \left\{ \begin{bmatrix} \text{PRED} & \text{`CLEARLY'} \end{bmatrix} \right\} \end{bmatrix}$$

A manner adverb like *skillfully* can be adjoined to VP, as in (62). Evidence that the adverb *skillfully* is adjoined to VP in this example comes from the VP preposing construction, discussed in Chapter 3, Section 4 and illustrated in (63), where a VP appears in fronted position. If the VP includes an adverb, the latter is also preposed, showing that the adverb forms a constituent with the VP.

(62) *David played skillfully.*



$$\begin{bmatrix} \text{PRED} & \text{`PLAY}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`David'} \end{bmatrix} \\ \text{ADJ} & \left\{ \begin{bmatrix} \text{PRED} & \text{`SKILLFULLY'} \end{bmatrix} \right\} \end{bmatrix}$$

(63) *David wants to play skillfully, and [play skillfully] he will.*

5.2. Adverbs and Semantic Composition

5.2.1. Adverb Meaning

The semantic contribution of adverbs has long been a focus of generative linguistic research. Heny (1973) gives a cogent overview of the state of research on adverb meaning in the early 1970s, when much research on adverb meaning was done; though it was conducted on the basis of very different syntactic assumptions, this work nevertheless forms the foundation upon which much current work on the semantics of adverbs is based. We will examine two semantically different kinds of adverbs, illustrated in the previous section by the sentential adverb *clearly* and the manner adverb *skillfully*.

Within the LFG semantic tradition, Halvorsen (1983) discusses sentential adverbs like *clearly* and *necessarily* and proposes to treat them in the standard way, as proposition modifiers. The meaning of the sentence *Clearly David fell* is therefore:

(64) *Clearly David fell.*

clearly(fall(David))

The predicate *clearly* takes as its argument the proposition *David fell*, and the meaning represented in (64) is roughly paraphrasable as *It is clear that David fell*.

Heny (1973), writing at the time at which Nixon was the president of the United States, considers the following pair of sentences:

(65) a. *The U.S. president is necessarily a citizen of the United States.*

b. *Nixon is necessarily a citizen of the United States.*

As Heny notes, sentence (65a) is true under the rules of the constitution of the United States, while sentence (65b) is not true by necessity. In other words, though it turns out to be true that Nixon is a citizen of the United States, this is not necessarily the case, since Nixon could have decided to become a citizen of another country. On the other hand, it is necessarily the case that the U.S. president must be a U.S. citizen under the laws of the United States. The sentences in (66), containing the sentential adverb *clearly*, differ from one another in a similar way:

(66) a. *Clearly the running back fell.*

b. *Clearly David fell.*

Even in a situation where the running back fell and David is the running back, it may not be clear that David fell, since the identity of the running back may not be certain. Adverbs like *clearly* and *necessarily* are opaque in their subject position, since different ways of referring to the same individual can affect the truth or falsity of the sentence (Quine 1953).

This aspect of the meaning of sentential adverbs is different from manner adverbs. Intuitively, a manner adverb like *skillfully* modifies the action that is performed, producing a new action that is performed skillfully:

(67) *David played skillfully.*

$\mathit{skillfully}(\mathit{David}, \lambda x.\mathit{play}(x))$

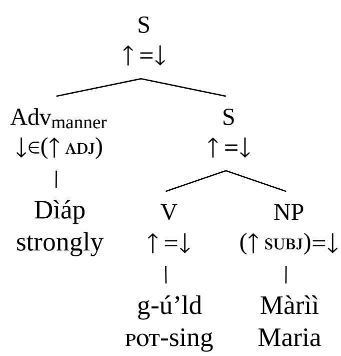
In (67), *skillfully* is a two-place predicate: its arguments are the person that performed the action (here, David) and the action that is performed skillfully (here, playing). Unlike the situation with sentential adverbs, the following two sentences are both true if David is the running back and he played skillfully. Manner adverbs like *skillfully* are not opaque in their subject position, so that if David is the running back, the sentences in (68) are true in the same circumstances.

(68) a. *David played skillfully.*

b. *The running back played skillfully.*

In general, a manner adverb like *skillfully* takes two arguments, one corresponding to the subject of the sentence and the other roughly corresponding to the English verb phrase — the action that is performed. For this reason, such adverbs are sometimes called *VP* or *verb phrase adverbs*, and as shown in (62) above, such adverbs can be adjoined to VP in English. However, meaning combination with adverbs like *skillfully* in fact depends on f-structural relations like SUBJ, not c-structure constituency relations. This is clearly shown by the existence of manner adverbs in languages without a VP constituent; Broadwell (2005) provides a detailed examination of the phrase structure of Zapotec, showing that Zapotec lacks a VP constituent, and that manner adverbs appear adjoined to S:

(69) *Dìáp g-ú'ld Màrìì.*
strongly POT-sing Maria
'Maria will sing strongly/loudly.'



5.2.2. Adverbs and Meaning Assembly

We assume the syntactic and semantic structures and meaning constructor in (70) for the sentence *Clearly David fell*. The f-structure for *clearly* is labeled *c*, and its semantic structure c_σ contains the attribute VAR whose value we have labeled *cv*:

(70) *Clearly David fell.*

$$f\left[\begin{array}{ll}\text{PRED} & \text{`FALL}\langle\text{SUBJ}\rangle\text{'}\\ \text{SUBJ} & d\left[\text{PRED}\quad \text{`DAVID'}\right]\\ \text{ADJ} & \left\{ c\left[\text{PRED}\quad \text{`CLEARLY'}\right]\right\}\end{array}\right] \dashrightarrow c_\sigma\left[\text{VAR}\quad \mathit{cv}[\ ]\right]$$

$\mathit{clearly}(\mathit{fall}(\mathit{David})) : f_\sigma$

From now on, we will simplify our representations by displaying only semantic structures whose internal structure is of interest in the constructions we are considering. Therefore, we do not display the semantic structures d_σ or f_σ corresponding to the subject f-structure d and the sentence f-structure f.

We propose this lexical entry for the sentential adverb *clearly*.

(71) Lexical entry for *clearly*:

clearly Adv $(\uparrow \text{PRED}) = \text{`CLEARLY'}$

$\lambda P.\mathit{clearly}(P) : (\uparrow_\sigma \text{VAR}) \multimap \uparrow_\sigma$

$\lambda P.\lambda Q.P(Q)$:

$[(\uparrow_\sigma \text{VAR}) \multimap \uparrow_\sigma] \multimap [(\text{ADJ} \in \uparrow)_\sigma \multimap (\text{ADJ} \in \uparrow)_\sigma]$

As in the previous sections, the lexical entry in (71) uses inside-out functional uncertainty to refer to the f-structure of the phrase it modifies. The expression $(\text{ADJ} \in \uparrow)$ refers to the f-structure modified by *clearly*, which in (70) is f. The first meaning constructor in (71) contributes the intrinsic, modifiable meaning of the adverb, and the second meaning constructor combines with the first one to produce a meaning capable of modifying a proposition. We assume that both of these meaning constructors are part of the lexical entry of the adverb, as in our analysis of attributive adjectives. Unlike adjectives, there is no independent predicative use of the intrinsic meaning of an adverb, as (72) illustrates, and so there is no other version of the adverb lexical entry which contains only the intrinsic meaning of the adverb and not the second meaning constructor.

(72) a. *David is happy.*

b. **David is clearly.* / **The situation is clearly.*

The instantiated meaning constructors for the sentence *Clearly David fell* are given in (73): the meaning constructors contributed by *clearly* are labeled **[clearly1]** and **[clearly2]**, and the meaning constructors **[David]** and **[fall]** follow the proposals for proper names and intransitive verbs given in Chapter 8.

(73) Meaning constructor premises for *Clearly David fell*:

$$\begin{array}{llcl}
\textbf{[David]} & \textit{David} & : & d_\sigma \\
\textbf{[fall]} & \lambda x.\textit{fall}(x) & : & d_\sigma \multimap f_\sigma \\
\textbf{[clearly1]} & \lambda P.\textit{clearly}(P) & : & cv \multimap c_\sigma \\
\textbf{[clearly2]} & \lambda P.\lambda Q.P(Q) & : & [cv \multimap c_\sigma] \multimap [f_\sigma \multimap f_\sigma]
\end{array}$$

Since the modifying adverb *clearly* is not itself modified, we first combine the two meaning constructor premises **[clearly1]** and **[clearly2]** to obtain this meaning constructor:

(74) **[clearly]** $\lambda Q.\textit{clearly}(Q) : [f_\sigma \multimap f_\sigma]$

As described in Chapter 8, Section 5.2.1, we can combine the premises labeled **[David]** and **[fall]** to obtain this meaning constructor:

(75) **[David-fall]** $\textit{fall}(\textit{David}) : f_\sigma$

Finally, we combine the meaning constructors **[David-fall]** and **[clearly]** to obtain the desired result, that is, the meaning of the sentence is $\textit{clearly}(\textit{fall}(\textit{David}))$:

(76) **[David-fall]**, **[clearly]** $\vdash$ $\textit{clearly}(\textit{fall}(\textit{David})) : f_\sigma$

The derivation is semantically complete and coherent: we have obtained a well-formed, nonimplicational meaning constructor for the sentence, with no premises left unused.

The meaning deduction of a sentence with the manner adverb *skillfully* proceeds somewhat differently. The syntactic and semantic structures and meaning constructor for the sentence *David played skillfully* are given in (77), where the semantic structure s_σ corresponding to the adverb f-structure has the attribute VAR with value *sv* and PROP with value *sp*:

(77) *David played skillfully.*

$$p\left[\begin{array}{ll}
\text{PRED} & \text{`PLAY}\langle\text{SUBJ}\rangle\text{'} \\
\text{SUBJ} & d\left[\begin{array}{ll}\text{PRED} & \text{`DAVID'}\end{array}\right] \\
\text{ADJ} & \left\{ s\left[\begin{array}{ll}\text{PRED} & \text{`SKILLFULLY'}\end{array}\right] \right\}
\end{array}\right] \dashrightarrow s_\sigma\left[\begin{array}{ll}
\text{VAR} & sv[\ ] \\
\text{PROP} & sp[\ ]
\end{array}\right]$$

$\textit{skillfully}(\textit{David}, \lambda x.\textit{play}(x)) : f_\sigma$

Again, we assume a bipartite semantic contribution for the adverb *skillfully*. The lexical entry for *skillfully* is given in (78), and the instantiated meaning constructor premises for this sentence are given in (79).

(78) *skillfully* Adv $(\uparrow \textsc{pred}) = \text{`}\textsc{skillfully}\text{'}$

$$\lambda Q.\lambda y.\mathit{skillfully}(y, Q) \;:\; [(\uparrow_\sigma \textsc{var}) \multimap (\uparrow_\sigma \textsc{prop})] \multimap [(\uparrow_\sigma \textsc{var}) \multimap \uparrow_\sigma]$$

$$\lambda P.\lambda Q.\lambda x.P(Q)(x) \;:\; [[(\uparrow_\sigma \textsc{var}) \multimap (\uparrow_\sigma \textsc{prop})] \multimap [(\uparrow_\sigma \textsc{var}) \multimap \uparrow_\sigma]] \multimap [((\textsc{adj} \in \uparrow)\ \textsc{subj})_\sigma \multimap (\textsc{adj} \in \uparrow)_\sigma] \multimap [((\textsc{adj} \in \uparrow)\ \textsc{subj})_\sigma \multimap (\textsc{adj} \in \uparrow)_\sigma]$$

(79) Meaning constructor premises for *David played skillfully*:

[David] $\mathit{David} \;:\; d_\sigma$

[play] $\lambda x.\mathit{play}(x) \;:\; d_\sigma \multimap p_\sigma$

[skillfully1] $\lambda Q.\lambda y.\mathit{skillfully}(y, Q) \;:\; [sv \multimap sp] \multimap [sv \multimap s_\sigma]$

[skillfully2] $\lambda P.\lambda Q.\lambda x.P(Q)(x) \;:\; [[sv \multimap sp] \multimap [sv \multimap s_\sigma]] \multimap [[d_\sigma \multimap p_\sigma] \multimap [d_\sigma \multimap p_\sigma]]$

We begin the derivation by combining the premises **[skillfully1]** and **[skillfully2]** to obtain this meaning constructor:

(80) **[skillfully]** $\lambda Q.\lambda y.\mathit{skillfully}(y, Q) : [d_\sigma \multimap p_\sigma] \multimap [d_\sigma \multimap p_\sigma]$

The right-hand side of the meaning contribution of the intransitive verb *play*, $d_\sigma \multimap p_\sigma$ exactly matches the requirements of **[skillfully]**. We combine **[skillfully]** and **[play]**, and obtain this meaning constructor:

(81) **[skillfully-play]** $\lambda y.\mathit{skillfully}(y, \lambda x.\mathit{play}(x)) : d_\sigma \multimap p_\sigma$

Finally, we combine **[skillfully-play]** and **[David]** to obtain a wellformed, semantically complete and coherent meaning constructor for the sentence:

(82) **[skillfully-play]**, **[David]** $\vdash\ \mathit{skillfully}(\mathit{David}, \lambda x.\mathit{play}(x)) : p_\sigma$

6. FURTHER READING AND RELATED ISSUES

There has been much work on modification within LFG, particularly on the syntax of modifiers and adjunction, that has not been discussed in this chapter. In particular, Butt et al. (1999) discuss the syntax of adjectives and adverbs in English, French, and German, and Colban (1987) provides a syntactic and semantic analysis of prepositional phrases as verbal arguments and modifiers. Mittendorf and Sadler (2008) discuss adjectival constructions in Welsh, and Al Sharifi and Sadler (2009) discuss the adjectival construct in Arabic. Vincent and Börjars (2010a), Raza and Ahmed (2011), and Lowe (2013) discuss complementation within noun and adjective phrases. Arnold and Sadler (2013) discuss displaced dependent constructions such as *too complex for anyone to understand*. A general overview of the syntax and semantics of coordination is given in Chapter 16, but we leave an analysis of coordinated modifiers (as in *tall and thin man*) for future work.

We have also omitted definition and discussion of the important issue of scoping relations between modifiers. As noted by Andrews (1983b), Andrews and Manning (1993), Pollard and Sag (1994), and many others, the contribution of modifiers to the meaning of an utterance can depend on the order in which they appear. Andrews (2016) discusses the contrast in (83), in which the modifiers *unscrupulous* and *former* appear in different orders: (83a) refers to someone who is unscrupulous and was a property developer in the past, while (83b) refers to someone who was an unscrupulous property developer in the past but may currently be neither unscrupulous nor a property developer.

(83) a. *He is an* <u>*unscrupulous*</u> <u>*former*</u> *property developer.*

b. *He is a* <u>*former*</u> <u>*unscrupulous*</u> *property developer.*

Various approaches to constraining modifier scope have been explored in an LFG setting. Some approaches define syntactic scoping relations between modifiers in terms of f-precedence (Chapter 6, Section 11.4); on such approaches, semantic scope relations are constrained by the syntactic scope relations determined by f-precedence. Andrews (2016) develops an alternative approach which introduces set-based nesting relations into the f-structure, resulting in a close match between f-structure embedding and the c-structure nesting relations that correlate with modifier scope. Meaning assembly can then take advantage of this additional structure to constrain modifier scope relations appropriately. Morrison (2017) builds on this approach in an analysis of displaced adjectival focus, including constraints on the position of relational adjectives.

14

ANAPHORA

A variety of types of anaphora are attested crosslinguistically. Section 1 of this chapter shows that incorporated pronominal elements behave differently from elements that alternate with agreement markers, and these differ from morphologically independent pronouns in interesting ways. Anaphoric relations and binding patterns have been fairly well studied in LFG; Section 2 discusses constraints on anaphoric binding stated in terms of structural relations holding at f-structure, and Section 3 discusses prominence relations which hold between the anaphor and its potential antecedents stated at f-structure as well as other linguistic levels. Our glue-theoretic treatment of the semantics of anaphoric binding is presented in Section 4.[1] This semantic treatment will be drawn upon in subsequent chapters, particularly in our discussion of *anaphoric control* in Chapter 15.

1. INCORPORATED PRONOUNS AND 'PRO-DROP'

As discussed in Chapter 5, Section 4.3, a predicate may specify information about how its arguments are interpreted when no overt argument phrases are present. In Chicheŵa, for example, a verb like *zi-ná-wá-lum-a* 'bite' provides

[1]The analyses presented in Sections 3.4 and 4 are the result of joint work with Dag Haug.

such information about its subject and its object. The OBJ affix *-wá-* is unambiguously an incorporated OBJ pronoun, so that a better gloss for this form might be 'bite them'. This incorporated pronominal OBJ may be anaphorically linked to a topic phrase, as in the English example *Those students, the bees bit them*.

In contrast, the SUBJ marker *zi-* behaves either as an agreement marker or as an incorporated pronoun. In the presence of an overt SUBJ phrase, *zi-* simply marks agreement with the subject. When no overt SUBJ phrase appears, *zi-* is an incorporated pronoun like the OBJ marker. Since the subject marker may behave as an incorporated pronoun, it can be anaphorically linked to a topic phrase, like the incorporated OBJ pronoun *-wá-*; the important difference between the two markers is that the SUBJ marker has an alternate use as an agreement marker in addition to its use as an incorporated pronominal.

As Bresnan and Mchombo (1987) show, there is a great deal of evidence for the different status of the SUBJ and OBJ markers in Chicheŵa. For example, since the subject marker can simply mark agreement, it can appear with an idiomatic subject. In contrast, the object marker is always an incorporated pronoun and not an object agreement marker, and it cannot appear with an idiomatic object, since an idiomatic object cannot be interpreted as an information structure topic and cannot bear an anaphoric relation to an incorporated pronominal object. Further, the subject can be questioned when the subject marker is present, but the object cannot be questioned when the object marker is present: since the question word bears the information structure focus function, it is compatible with the subject agreement marker, but not with the incorporated pronominal OBJ, which must bear an anaphoric relation to an information structure topic and not a focus. Bresnan and Mchombo (1987) enumerate additional ways in which the SUBJ and OBJ markers behave differently, showing that all of these differences can be explained on the basis of the different status of the two markers.

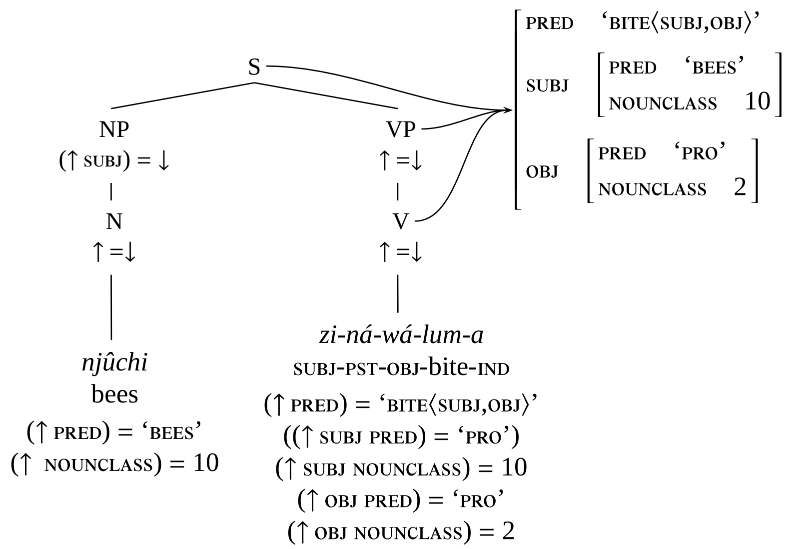
The syntactic difference between the SUBJ and OBJ affixes is formally reflected in the following lexical entry.

(1) Lexical entry for the Chicheŵa verb *zi-ná-wá-lum-a*:

zináwáluma	V	$(\uparrow \text{PRED}) = \text{'BITE}\langle\text{SUBJ,OBJ}\rangle\text{'}$
		$((\uparrow \text{SUBJ PRED}) = \text{'PRO'})$
		$(\uparrow \text{SUBJ NOUNCLASS}) = 10$
		$(\uparrow \text{OBJ PRED}) = \text{'PRO'}$
		$(\uparrow \text{OBJ NOUNCLASS}) = 2$

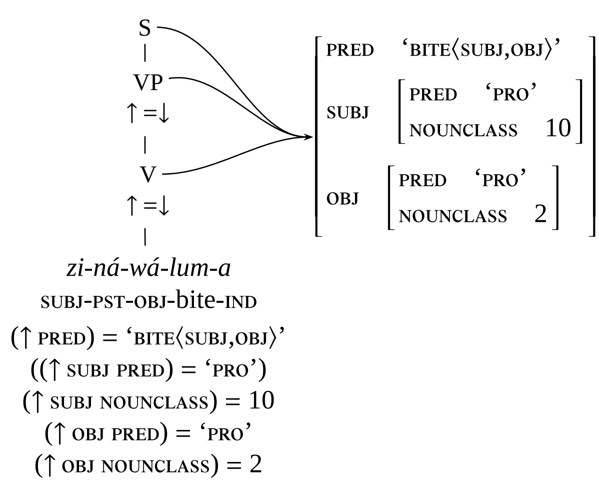
In this lexical entry, the PRED value of the OBJ of *zi-ná-wá-lum-a* 'bite' is unambiguously specified by the equation $(\uparrow \text{OBJ PRED}) = \text{'PRO'}$: the object of this verb is pronominal. In contrast, the PRED value of the SUBJ is optionally specified, as indicated by the parentheses. In the presence of an overt SUBJ phrase, the subject marker specifies only agreement information (here, information about noun class), and the PRED value of the SUBJ is provided by the overt subject phrase, as shown in (2).

(2) *njûchi zi-ná-wá-lum-a*
bees SUBJ-PST-OBJ-bite-IND
'The bees bit them.'



In contrast, (3) shows that when there is no subject phrase, the specifications associated with the verb provide the PRED value for the SUBJ.

(3) *zi-ná-wá-lum-a*
SUBJ-PST-OBJ-bite-IND
'They bit them.'



As discussed in Chapter 5, Section 4, the typology of agreement and pronominal incorporation that is reflected in these different specifications is richer than is assumed in some other theories. In her analysis of nonconfigurationality, Jelinek (1984) proposes that all nonconfigurational languages should be analyzed as pronominal-incorporating, as we have analyzed the Chicheŵa incorporated object pronoun. Bresnan and Mchombo (1987) conclusively demonstrate that this inflexible approach is incorrect and that a wider range of distinctions is necessary. The object marking on the Chicheŵa verb must be analyzed as an incorporated pronoun with an obligatory pronominal PRED value supplied by the verb, while the subject marking represents an optional pronominal PRED, behaving as an agreement marker in the presence of an overt subject phrase. Further evidence for the richer typology assumed in LFG is provided by Austin and Bresnan (1996) in their analysis of Warlpiri, Toivonen (2001) in her analysis of Finnish, Butt (2007) in her analysis of Punjabi, and Coppock and Wechsler (2012) in their analysis of Hungarian.

Bresnan et al. (2016) provide much more discussion of the typology of pronominal elements in LFG, including a detailed discussion of the differences between overt pronouns and "null" pronominals like the Chicheŵa incorporated OBJ pronoun. In their Chapter 8, Bresnan et al. (2016) explore the role of null pronominals in introducing and referring to sentential and discourse topics, and in focus constructions.

2. BINDING RELATIONS

Anaphoric binding relations are semantic in nature, having to do with coreference between a pronoun and its antecedent: this is the topic of Section 4. Nonsemantic levels of linguistic structure also play a role in anaphoric binding, as we discuss in Section 3, since they are often important in constraining possible binding relations. In this section, we discuss constraints on the binding relation which are defined in terms of f-structure domains and relations. We assume the phrase structure rules and lexical entries that we have discussed so far, and we display only the f-structures for the examples under discussion.

Within LFG, Bresnan et al. (1985a) were the first to propose that a theory of syntactic constraints on binding relations can be stated in terms of f-structural properties such as coargumenthood or the presence of a SUBJ function. Continuing this work, Dalrymple (1993) proposed a universally available and lexically specified inventory of binding constraints, and also provided a formal specification of these constraints. This work has been extended by many others, including Strand (1992) in work on Norwegian anaphora, Sung (1996) in work on Korean, Lapata (1998) in work on Modern Greek, Henadeerage (1998) in work on Sinhala, Lødrup (2008a) in work on Norwegian, Strahan (2009, 2011) in work on Icelandic and other Scandinavian languages, Rákosi (2009, 2010) in work on Hungarian, Snijders (2014) in work on Warlpiri, and Dalrymple (2015) in work on Yag̨ Dii. Bresnan et al. (2016, Chapters 10–11) provide a detailed discussion of binding constraints, extending the theory to cover coreference relations between nonpronominal elements as well. In the following, we give a brief overview of the theory.

2.1. Positive Binding Constraints

Some anaphoric elements, such as the English reflexive pronoun *himself*, must appear in a particular syntactic relation to their antecedent. We say that elements like *himself* obey *positive constraints*, that is, constraints which state the syntactic relation that an anaphor must bear to its antecedent.

Example (4) is potentially ambiguous since the antecedent of *himself* can be either the SUBJ *David* or the OBJ *Chris*. Here we focus on the reading on which the antecedent of *himself* is *David*, as indicated by the subscript *i* annotation coindexing *David* and *himself*:

(4) *David$_i$ compared Chris to himself$_i$.*

$$c\left[\begin{array}{ll}
\text{PRED} & \text{`COMPARE}\langle\text{SUBJ,OBJ,OBL}_{\text{TO}}\rangle\text{'} \\
\text{SUBJ} & \left[\text{PRED} \quad \text{`DAVID'}\right] \\
\text{OBJ} & \left[\text{PRED} \quad \text{`CHRIS'}\right] \\
\text{OBL}_{\text{TO}} & \left[\begin{array}{ll}
\text{PRED} & \text{`PRO'} \\
\text{PRONTYPE} & \text{REFL} \\
\text{INDEX} & \left[\begin{array}{ll}
\text{PERS} & 3 \\
\text{NUM} & \text{SG} \\
\text{GEND} & \text{M}
\end{array}\right]
\end{array}\right]
\end{array}\right]$$

In the f-structure in (4), the antecedent *David* of the reflexive pronoun *himself* is the SUBJ of the f-structure labeled *c*, and the reflexive pronoun is the OBL_{TO} of the same f-structure. The semantic antecedency relation, which establishes coreference between the anaphor and its antecedent, is defined and discussed in Section 4.3; here we concentrate on syntactic factors that constrain the anaphor-antecedent relation.

The antecedent of *himself* may also appear in a larger f-structure. In (5), *David* is an acceptable antecedent of *himself*, even though *himself* is the object of the preposition *around*, and *David* is the subject of the verb *wrapped*:

(5) *David$_i$ wrapped the blanket around himself$_i$.*

$$\left[\begin{array}{ll}
\text{PRED} & \text{‘WRAP}\langle\text{SUBJ,OBJ,OBL}_{\text{LOC}}\rangle\text{’}\\
\text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{‘David’}\end{array}\right]\\
\text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{‘BLANKET’}\\ \text{DEF} & +\end{array}\right]\\
\text{OBL}_{\text{LOC}} & \left[\begin{array}{ll}\text{PRED} & \text{‘AROUND}\langle\text{OBJ}\rangle\text{’}\\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{‘PRO’}\\ \text{PRONTYPE} & \text{REFL}\\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3\\ \text{NUM} & \text{SG}\\ \text{GEND} & \text{M}\end{array}\right]\end{array}\right]\end{array}\right]
\end{array}\right]$$

However, it is not possible for *himself* to appear in a sentence with no antecedent, or with an antecedent in a syntactically unacceptable relation to it. For example, *himself* may not be separated from its antecedent by a finite clause boundary:

(6) **David$_i$ thought that Susan had seen himself$_i$.*

$$\left[\begin{array}{ll}
\text{PRED} & \text{‘THINK}\langle\text{SUBJ,COMP}\rangle\text{’}\\
\text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{‘David’}\end{array}\right]\\
\text{COMP} & \left[\begin{array}{ll}\text{PRED} & \text{‘SEE}\langle\text{SUBJ,OBJ}\rangle\text{’}\\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{‘Susan’}\end{array}\right]\\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{‘PRO’}\\ \text{PRONTYPE} & \text{REFL}\\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3\\ \text{NUM} & \text{SG}\\ \text{GEND} & \text{M}\end{array}\right]\end{array}\right]\end{array}\right]
\end{array}\right]$$

As demonstrated by Bresnan et al. (1985a), the English reflexive pronoun *himself* obeys the following positive constraint, governing the syntactic relation between *himself* and its antecedent:

(7) The antecedent of the English reflexive pronoun *himself* must appear in the *Minimal Complete Nucleus* containing the pronoun.

The Minimal Complete Nucleus is defined by reference to the presence of a SUBJ function (Bresnan et al. 1985a; Dalrymple 1993; Bresnan et al. 2016):

(8) Minimal Complete Nucleus containing an f-structure *p*:

The smallest f-structure that contains *p* and a SUBJ function.

According to this definition, the antecedent of the anaphor *himself* must appear in the smallest f-structure that contains both the anaphor and a SUBJ. We call the domain in which the antecedent of the anaphor must appear the *binding domain* of the anaphor, and we say that the binding domain of *himself* is the Minimal Complete Nucleus.

Languages with multiple anaphors provide evidence for expanding the range of constraints that anaphors can obey and also demonstrate that constraints on anaphoric binding must be specified lexically, not universally or on a per-language basis: different anaphoric elements in the same language may obey different anaphoric binding constraints. The pronominal system of Norwegian is particularly rich.[2]

Hellan (1988) shows that although both the Norwegian reflexive anaphor *seg selv* and the reciprocal *hverandre* must be locally bound, the binding domain for the reciprocal *hverandre* is larger than the domain for *seg selv*. The reflexive *seg selv* must be bound to a *coargument*, an argument governed by the same PRED as the reflexive. In contrast, the reciprocal *hverandre*, like the English reflexive pronoun *himself*, must be bound in the Minimal Complete Nucleus.

In (9), the verb *fortalte* 'told' has three arguments: SUBJ, OBJ, and an $\text{OBL}_{\text{ABOUT}}$ argument marked by the preposition *om*. The antecedent of the $\text{OBL}_{\text{ABOUT}}$ *seg selv* is the SUBJ, *Jon* (Hellan 1988, page 67):

(9) *Jon fortalte meg om seg selv.*
Jon told me about self
'Jon$_i$ told me about self$_i$.'

$$\left[\begin{array}{ll} \text{PRED} & \text{`TELL}\langle\text{SUBJ,OBJ,OBL}_{\text{ABOUT}}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`JON'} \end{array}\right] \\ \text{OBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{INDEX} & \left[\begin{array}{ll} \text{PERS} & 1 \\ \text{NUM} & \text{SG} \end{array}\right] \end{array}\right] \\ \text{OBL}_{\text{ABOUT}} & \left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{PRONTYPE} & \text{REFL} \\ \text{INDEX} & \left[\begin{array}{ll} \text{PERS} & 3 \end{array}\right] \end{array}\right] \end{array}\right]$$

[2]Hellan (1988), Strand (1992), and Dalrymple (1993) provide further discussion of binding constraints on Norwegian anaphors. In a very interesting series of articles, Lødrup (1999a, 2007, 2008a) challenges some of Hellan's generalizations and provides alternative analyses of binding constraints for the anaphoric elements in Norwegian, while maintaining the generalization that binding constraints can differ for different anaphoric elements.

In (9), the antecedent of *seg selv* is a coargument, as required: both *seg selv* and *Jon* are arguments of the verb *fortalte* ‘tell’. In contrast, (10) is ungrammatical:

(10) **Hun kastet meg fra seg selv.*
she threw me from self
‘She$_i$ threw me away from herself$_i$.’

$$\left[\begin{array}{ll}
\text{PRED} & \text{‘THROW}\langle\text{SUBJ,OBJ}\rangle\text{’}\\[4pt]
\text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{‘PRO’}\\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3\\ \text{NUM} & \text{SG}\end{array}\right]\end{array}\right]\\[4pt]
\text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{‘PRO’}\\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 1\\ \text{NUM} & \text{SG}\end{array}\right]\end{array}\right]\\[4pt]
\text{ADJ} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{‘FROM}\langle\text{OBJ}\rangle\text{’}\\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{‘PRO’}\\ \text{PRONTYPE} & \text{REFL}\\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3\end{array}\right]\end{array}\right]\end{array}\right]\right\}
\end{array}\right]$$

In (10), the verb *kastet* ‘threw’ takes only two arguments, SUBJ and OBJ; the phrase *fra seg selv* is an adjunct. The reflexive pronoun *seg selv* is the OBJ of the preposition *fra* ‘from’, and the intended antecedent is the SUBJ of the verb *kastet* ‘throw’. The reflexive and its intended antecedent are not coarguments of the same PRED, and the sentence is unacceptable.

Example (11) contains the Norwegian reciprocal pronoun *hverandre*, whose antecedent is the coargument SUBJ *de* ‘they’ (Hellan 1988, page 67). The f-structure for (11) is roughly the same as the one displayed in (9) for the reflexive *seg selv*:

(11) *De fortalte meg om hverandre.*
they told me about each other
‘They$_i$ told me about each other$_i$.’

The antecedent of the reciprocal *hverandre* is not required to be a coargument. The structure of (12) is similar to (10), but (12) is completely acceptable with the reciprocal *hverandre*, since the reciprocal appears in the Minimal Complete Nucleus with respect to its antecedent, as required (Hellan 1988, page 69).

(12) *De kastet meg til og fra hverandre.*
they threw me to and from each other
‘They$_i$ threw me to and from each other$_i$.’

These examples show that different anaphors in the same language may be required to obey different binding constraints. Thus, these constraints must be lexically specified for each anaphoric element.

Crosslinguistic examination of anaphoric binding patterns reveals four domains relevant for anaphoric binding, defined by the f-structure properties PRED, SUBJ, and TENSE, and by the entire sentence.

(13)

Coargument Domain:	minimal domain defined by a PRED and the grammatical functions it governs
Minimal Complete Nucleus:	minimal domain with a SUBJ function
Minimal Finite Domain:	minimal domain with a TENSE attribute
Root Domain:	f-structure of the entire sentence

Interestingly, all of these domains denote some syntactically or semantically complete entity: the Coargument Domain corresponds to a syntactically saturated argument structure, the Minimal Complete Nucleus corresponds to a predication involving some property and a subject, the Minimal Finite Domain represents an event that has been spatiotemporally anchored, and the Root Domain represents a complete sentence. The binding conditions defined in (13) are illustrated by the binding requirements for the Norwegian anaphors *seg selv*, *sin*, and *seg* (Hellan 1988) and the Chinese anaphor *ziji* (Tang 1989); see Dalrymple (1993) for more discussion.

(14) Positive binding domains:

Coargument domain	Minimal complete nucleus	Minimal finite domain	Root domain
seg selv	*sin*	*seg*	*ziji*

These binding requirements are specified as part of the lexical entry of each anaphoric element (Dalrymple 1993). They limit the possibilities for pronoun antecedency, which, as we show in Section 3.2 and Section 3.3, may be further constrained by other levels of structure.

Formally, we can define the syntactic domain in which an anaphor must find its antecedent by means of expressions involving *inside-out functional uncertainty*. As discussed in Chapter 6, Section 1.3, inside-out functional uncertainty allows reference to enclosing structures, those in which a particular f-structure is contained. In the case at hand, we can use inside-out functional uncertainty to define the binding domain of an anaphor, that is, the f-structure domain within which the anaphor is required to find its antecedent.

Assuming that the f-structure for the pronoun is p, we can define each of the anaphoric binding domains as follows.

(15) Coargument Domain: $(\underset{\neg(\rightarrow \textsc{pred})}{\textsc{gf}^*}\ \textsc{gf}_{pro}\ p)$

Minimal Complete Nucleus: $(\underset{\neg(\rightarrow \textsc{subj})}{\textsc{gf}^*}\ \textsc{gf}_{pro}\ p)$

Minimal Finite Domain: $(\underset{\neg(\rightarrow \textsc{tense})}{\textsc{gf}^*}\ \textsc{gf}_{pro}\ p)$

Root Domain: $(\textsc{gf}^*\ \textsc{gf}_{pro}\ p)$

These expressions constrain the f-structure domain within which the antecedent of the anaphor can appear. Recall that GF is an abbreviation for any grammatical function (Chapter 6, Section 1.2). In the expressions in (15), the path leading to the anaphor through the binding domain is as follows.

(16) Path defining the binding domain:

$\textsc{gf}^*\ \textsc{gf}_{pro}$

For clarity, we use the abbreviation $\textsc{gf}_{pro}$ for the grammatical function borne by the anaphoric pronoun, which can be any grammatical function. Constraints on the domain within which the anaphor must be bound are stated by means of *off-path constraints* on the path to the anaphor.[3] In the case of the Coargument Domain definition, for example, the path leading through the binding domain to the anaphor is as follows.

(17) Coargument Domain path:

$\underset{\neg(\rightarrow \textsc{pred})}{\textsc{gf}^*}\ \textsc{gf}_{pro}$

This expression is defined in terms of a series of attributes GF, each of which must obey the off-path constraint $\neg(\rightarrow \textsc{pred})$. In this expression, the symbol $\rightarrow$ refers to the f-structure value of the attribute GF, and the expression $\neg(\rightarrow \textsc{pred})$ represents a negative existential constraint preventing that f-structure from containing the attribute PRED. The effect of this constraint is that the path through the binding domain leading to the anaphor may not pass through an f-structure containing the attribute PRED. If the path were to pass through such an f-structure, the binding domain would incorrectly extend beyond the Coargument Domain.

The other binding domains are similarly defined by off-path constraints that prevent the path from passing through an f-structure of a certain type. For anaphors subject to the Minimal Complete Nucleus constraint, the path from the pronoun to its antecedent may not pass through an f-structure with a SUBJ attribute, and for the Minimal Finite Domain constraint, an f-structure with a TENSE attribute may not be crossed. For the Root Domain, the path is unconstrained and may be of arbitrary length. In this way, anaphors that obey positive constraints are required to find an antecedent within a certain f-structural domain.

[3] Off-path constraints are defined and discussed in Chapter 6, Section 6.

Although the antecedent of the anaphor must appear within its binding domain, antecedents that are too deeply embedded within the binding domain are not acceptable:

(18) * *David$_i$'s mother nominated himself$_i$.*

$$\left[\begin{array}{ll} \text{PRED} & \text{`NOMINATE}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll} \text{POSS} & \left[\begin{array}{ll}\text{PRED} & \text{`DAVID'}\end{array}\right] \\ \text{PRED} & \text{`MOTHER'} \end{array}\right] \\ \text{OBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{PRONTYPE} & \text{REFL} \\ \text{INDEX} & \left[\begin{array}{ll} \text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{GEND} & \text{M} \end{array}\right] \end{array}\right] \end{array}\right]$$

As noted in Chapter 6, Section 9.1, the antecedent of an anaphor is generally required to *f-command* the anaphor.[4] In (18) the intended antecedent *David* of the reflexive *himself* appears in the proper binding domain, the Minimal Complete Nucleus; however, the f-command condition does not hold, and the sentence is ill-formed.

The syntactic relation between the anaphor and its antecedent is given by a constraint of the following form, where GF_{ante} is the grammatical function of the antecedent.

(19) F-commanding f-structures:

$$((\text{GF}^{*}\ \text{GF}_{pro}\ p)\ \text{GF}_{ante})$$

In this expression, as above, p is the f-structure for the anaphor, and $(\text{GF}^{*}\ \text{GF}_{pro}\ p)$ defines the binding domain containing the anaphor and its antecedent. The expression in (19) refers to some f-structure within the binding domain which bears the unspecified grammatical function GF_{ante}. The f-command requirement follows from the form of this expression, since the expression in (19) picks out all and only the f-structures that f-command the anaphor within the binding domain.

In the expression in (19), the grammatical function of the antecedent GF_{ante} is unconstrained, and any grammatical function may be chosen. In some cases, however, the grammatical function of the antecedent may also be constrained in that the antecedent of the anaphor may be required to bear either the function SUBJ or the function POSS within the binding domain. Hellan (1988) shows that the antecedent of the Norwegian possessive reflexive *sin* must be a subject:

(20) a. *Jon ble arrestert i sin kjøkkenhave.*
Jon was arrested in self's kitchen.garden

[4] See Culy (1991) for discussion of the Fula pronominal *ɗum*, which is unusual in not obeying a command condition.

‘Jon$_i$ was arrested in his$_i$ kitchen garden.’

b. **Vi arresterte Jon i sin kjøkkenhave.*
we arrested Jon in self’s kitchen.garden
‘We arrested Jon$_i$ in his$_i$ kitchen garden.’

In contrast, nonsubjects are acceptable antecedents for the Norwegian possessive pronoun *hans*:

(21) *Vi fant Jon under sengen hans.*
we found Jon under bed his
‘We found Jon$_i$ under his$_i$ bed.’

Thus, it is necessary in some cases, including Norwegian *sin*, to constrain the grammatical function of the antecedent. The following expression picks out all subjects within the Minimal Finite Domain relative to the pronoun f-structure *p*.

(22) F-commanding subjects in the Minimal Finite Domain:

$$((\underset{\neg(\rightarrow\ \mathrm{TENSE})}{\mathrm{GF}^*}\ \mathrm{GF}_{\mathrm{pro}}\ p)\ \mathrm{SUBJ})$$

F-structures with the SUBJ function in other domains are picked out similarly; see Dalrymple (1993) and Bresnan et al. (2016) for details.

Other conditions on the antecedent must also be met in some cases. Culy (1996) discusses the pronominal systems of several varieties of Fula in which certain pronouns place very specific syntactic requirements on their antecedents: for instance, that the antecedent must be a pronoun. Culy analyzes this as a type of agreement between the pronoun and its antecedent.

2.2. Negative Binding Constraints

Just as some anaphoric elements require their antecedent to appear within some syntactic domain, some elements can require noncoreference with every element within some domain. We call such noncoreference constraints *negative constraints*. For instance, the pronoun *him* may not corefer with its coargument *Chris* in this example:

(23) **Chris$_i$ nominated him$_i$.*

$$\begin{bmatrix} \mathrm{PRED} & \text{‘NOMINATE}\langle\mathrm{SUBJ,OBJ}\rangle\text{’} \\ \mathrm{SUBJ} & \begin{bmatrix} \mathrm{PRED} & \text{‘CHRIS’} \end{bmatrix} \\ \mathrm{OBJ} & \begin{bmatrix} \mathrm{PRED} & \text{‘PRO’} \\ \mathrm{INDEX} & \begin{bmatrix} \mathrm{PERS} & 3 \\ \mathrm{NUM} & \mathrm{SG} \\ \mathrm{GEND} & \mathrm{M} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The constraint obeyed by *him* can be stated in the following way:

(24) The antecedent of the English pronoun *him* must not appear in the Coargument Domain containing the pronoun.

We formalize this in Section 4.3 below.

Different anaphoric elements in the same language may obey different negative constraints. Thus, as with positive constraints, negative constraints must be lexically associated with the relevant anaphoric elements. Interestingly, the same domains that are relevant for defining positive constraints, described in Section 2.1, are also relevant for negative constraints, as Dalrymple (1993) shows for the Norwegian pronouns *ham selv* and *seg* (Hellan 1988), the Hindi possessive pronoun *uskaa* (Mohanan 1994), and the Yoruba pronoun *ó* (Pulleyblank 1986).

(25) Negative binding domains:

Coargument domain	Minimal complete nucleus	Minimal finite domain	Root domain
seg	*ham selv*	*uskaa*	*ó*

In the case of positive constraints, the anaphor is required to corefer with *some* element picked out by the constraint; in the case of negative constraints, the anaphor must be noncoreferent with *all* elements picked out by the constraint.

2.3. Positive and Negative Binding Constraints

Since positive and negative constraints are lexically associated with individual anaphors, we would expect to find anaphors that simultaneously obey both kinds of constraints. The Norwegian anaphoric element *ham selv* exemplifies this situation (Hellan 1988; Dalrymple 1993): *ham selv* must be bound to an argument in the Minimal Complete Nucleus (a positive constraint), but it is also required to be noncoreferent with a coargument SUBJ (a negative constraint).

In (26a), the OBJ *Jon* and the oblique phrase *ham selv* are coarguments. Therefore, *ham selv* is coreferent with a coargument in (26a); (26b) shows that coreference with noncoarguments is also permitted:

(26) a. *Vi fortalte Jon om ham selv.*
we told Jon about self
'We told Jon$_i$ about self$_i$.'

b. *Jeg ga Jon en bok om ham selv.*
I gave Jon a book about self
'I gave Jon$_i$ a book about self$_i$.'

The antecedent of *ham selv* must appear in the Minimal Complete Nucleus containing it. This accounts for the unacceptability of (27), since the intended antecedent *Jon* does not appear in the Minimal Complete Nucleus relative to *ham selv*:

(27) **Jeg lovet Jon [å snakke om ham selv].*
I promised Jon to talk about self

'I promised Jon$_i$ to talk about self$_i$.'

However, *ham selv* may not corefer with a coargument subject, even one that is in its Minimal Complete Nucleus:

(28) * *Jon snakker om ham selv.*
Jon talks about self
'Jon$_i$ talks about self$_i$.'

Thus, the Norwegian pronoun *ham selv* obeys two binding conditions, one negative and one positive: it must be noncoreferent with a SUBJ coargument, and it must be coreferent with an argument in the Minimal Complete Nucleus. Both of these requirements must be satisfied. This is accomplished by including both a positive constraint and a negative constraint in the lexical entry for *ham selv*.

3. BINDING AND PROMINENCE

As discussed by Dalrymple (1993, Chapter 5) and Bresnan et al. (2016), not all f-commanding elements in the binding domain are relevant for the application of binding constraints, only those which are more *prominent* than the anaphor. In this section, we discuss prominence relations defined in terms of the grammatical function hierarchy (Section 3.1), f-precedence (Section 3.2), and argument structure (Section 3.3). Bresnan et al. (2016) show that different anaphors impose different combinations of prominence constraints in the statement of binding constraints. Evidence of binding constraints defined at multiple levels of structure has also been explored by Dalrymple (1993) for English and Norwegian and by Arka and Wechsler (1996) for Balinese. Arka and Wechsler show that constraints on Balinese binding relations depend on linear order, thematic prominence, and the term/oblique distinction. We provide a formal statement of prominence conditions in Section 3.4.

3.1. Prominence and the Grammatical Function Hierarchy

As we have seen, the English pronoun *him* obeys the negative Coargument Condition, and may not corefer with a coargument. However, (29) is wellformed despite *him* being coreferent with a coargument, *himself*:

(29) *I compared him$_i$ with himself$_i$.*

Similarly, in (30) the pronoun *him* is the object of *believe* and also the subject of *like*, and *himself* is the object of *like*. This means that *him* and *himself* are coarguments of *like*, but this does not lead to ungrammaticality:

(30) *I believed him$_i$ to like himself$_i$.*

As these examples show, coreference with certain coarguments does not violate the negative binding constraints which *him* obeys. In contrast, *him* in (31a) cannot corefer with the object of *compare*, and *him* as the object of *like* cannot corefer with the subject of *like*, *David* (31b).

(31) a. **I compared David*$_i$ *with him*$_i$.

b. **I believed David*$_i$ *to like him*$_i$.

Only arguments which are superior on the grammatical function hierarchy are relevant for the binding constraints associated with *him*. Bresnan et al. (2016, page 230) refer to this requirement as the *syntactic rank* condition, and require binding constraints to be defined in terms of syntactic rank:

(32) **Syntactic rank:** *A* locally outranks *B* if *A* and *B* belong to the same f-structure and *A* is more prominent than *B* on the grammatical function hierarchy. *A* outranks *B* if *A* locally outranks some *C* which contains *B*.

3.2. Prominence and F-Precedence

In addition to constraints on anaphoric binding defined purely in terms of f-structure properties, some pronouns obey constraints that are defined in terms of f-precedence relations holding between the anaphor and its antecedent. For example, Mohanan (1983) shows that overt pronouns in Malayalam cannot precede their antecedents:

(33) *[kuṭṭiyute ammaye] awan n̲uḷḷi*
child.GEN mother.ACC he pinched
'He$_i$ pinched the child$_i$'s mother.'

(34) **[awante ammaye] kuṭṭi n̲uḷḷi*
his mother.ACC child pinched
'The child$_i$ pinched his$_i$ mother.'

In (35), an overt pronoun is not acceptable if coreference with the matrix subject is intended:

(35) *[awan aanaye n̲uḷḷiyat̲inə s̄eeṣam] kuṭṭi uraŋŋi*
he elephant.ACC pinched after child slept
'The child$_i$ slept, after he$_{*i,j}$ pinched the elephant.'

However, pronominals that are not overtly realized at c-structure do not obey such ordering restrictions. The subordinate clause in (36) contains a null pronoun that may corefer with the matrix subject *kuṭṭi* 'child':

(36) *[∅ aanaye n̲uḷḷiyat̲inə s̄eeṣam] kuṭṭi uraŋŋi*
elephant.ACC pinched after child slept
'The child$_i$ slept, after he$_{i,j}$ pinched the elephant.'

Kameyama (1985) examines similar data from Japanese, discussed in Chapter 6, Section 11.4, and proposes the following generalization, valid for pronouns in Japanese, Malayalam, and many other languages:

(37) The antecedent of a pronoun must *f-precede* the pronoun.

As noted in Chapter 6, Section 11.4, constraining binding relations by f-precedence makes exactly the right predictions concerning overt and null elements.

Intuitively, an f-structure f f-precedes an f-structure g if the c-structure nodes corresponding to f precede the c-structure nodes corresponding to g. The formal definition of f-precedence provided by Kaplan and Zaenen (1989b) is given in (184) of Chapter 6, Section 11.4, and repeated here.

(38) F-precedence:

f *f-precedes* g ($f <_f g$) if and only if for all $n_1 \in \phi^{-1}(f)$ and for all $n_2 \in \phi^{-1}(g)$, n_1 c-precedes n_2.

This definition, together with the generalization in (37), predicts the patterns of acceptability for the Japanese and Malayalam examples examined above: null pronouns f-precede and are f-preceded by every element in the sentence, so no matter where the antecedent of a null pronoun appears in the sentence, the condition in (37) is satisfied. In contrast, overt pronouns are not permitted to f-precede their antecedents, accounting for the unacceptability of coreference in examples (34) and (35).

Bresnan (1995, 1998) and Bresnan et al. (2016) also discuss linear precedence conditions on anaphoric binding with particular attention to *weak crossover violations* in extraction, providing a different definition of f-precedence. We discuss these proposals in Chapter 17, Section 4.2.

3.3. Prominence and Argument Structure

As discussed in Chapter 2, Section 1.3, binding may also be constrained by argument structure relations: the antecedent of an anaphor may be required to outrank the anaphor or a phrase containing it on the *thematic hierarchy*. The thematic hierarchy presented in (25) of Chapter 9, Section 4.2 is repeated here.

(39) Thematic hierarchy:

AGENT > BENEFACTIVE > RECIPIENT/EXPERIENCER
> INSTRUMENT > THEME/PATIENT > LOCATIVE

Sells (1988) shows that reference to the thematic hierarchy is necessary in an account of binding conditions in Albanian. A term argument in Albanian can antecede a term or oblique reflexive, while an oblique can only antecede another oblique. Among the term arguments, binding relations are constrained by the thematic hierarchy: if the antecedent and the anaphor are both terms, the antecedent must be higher on the thematic hierarchy than the anaphor.

Hellan (1988), Dalrymple and Zaenen (1991), and Dalrymple (1993) discuss Norwegian data that point to a similar conclusion. Hellan (1988) shows that some Norwegian verbs have two possibilities for passivization:

(40) a.

Vi	*overlot*	*Jon*	*pengene.*
we	gave	Jon	money
		GOAL	THEME

'We gave Jon the money.'

b.

Jon	*ble*	*overlatt*	*pengene.*
Jon	was	given	money
GOAL			THEME

'Jon was given the money.'

c.

Pengene	*ble*	*overlatt*	*Jon.*
money	was	given	Jon
THEME			GOAL

'The money was given to Jon.'

However, when the object contains a possessive reflexive whose antecedent is the subject of the passive verb, only one reading is possible (Hellan 1988, page 162):

(41)

Barnet	*ble*	*fratatt*	*sine*	*foreldre.*
child	was	taken	self's	parents

'The child$_i$ was deprived of self's$_i$ parents.'
MALEFACTIVE THEME

NOT: 'The child$_i$ was taken away from self's$_i$ parents.'
THEME MALEFACTIVE

We might expect that either argument in (41) could be interpreted as the theme and either as the malefactive, in the same way that there is flexibility in (40). In fact, however, the only possible construal of this sentence is one where the subject *barnet* is the malefactive argument, and the object *sine foreldre* is the theme. Assuming that the goal and malefactive arguments occupy the same position on the thematic hierarchy, the malefactive argument outranks the theme argument. In the permissible reading of (41), then, the antecedent *barnet* outranks the phrase containing the pronoun *sine foreldre* on the thematic hierarchy. The other reading, where the phrase containing the pronoun thematically outranks the antecedent, is not available.

3.4. Prominence Constraints

Formally, we impose prominence conditions by constraining the relation between the potential antecedent and the f-structure containing the anaphor which appears in the same f-structure as the antecedent, just as in the syntactic rank condition defined in (32). Recall that the f-structures of the potential antecedents of an anaphor are those which f-command the anaphor, as shown in (19) and repeated here.

(42) F-commanding f-structures:

$$((\textsc{gf}^* \ \textsc{gf}_{\text{pro}} \ p) \ \textsc{gf}_{\text{ante}})$$

We can restrict application of binding constraints to f-structures which are more prominent than the anaphor by imposing constraints on $\textsc{gf}_{\text{ante}}$ of the form in (43), using the name PROMINENT as a cover term for prominence relations defined in terms of the grammatical function hierarchy, f-precedence, or the thematic hierarchy. As a part of the expression in (42), this constraint is lexically associated with the anaphor.

(43) Off-path constraints on $\textsc{gf}_{\text{ante}}$ encoding the prominence condition ($\textsc{gf}_{\text{ante}}$ is as shown in 42):

$$\begin{array}{c} \textsc{gf}_{\text{ante}} \\ \%\textsc{coarg} = (\leftarrow \textsc{gf}) \\ (\%\textsc{coarg}\ \textsc{gf}^*) = \uparrow \\ \textsc{prominent}(\rightarrow, \%\textsc{coarg}) \end{array}$$

In (42) and (43), $\textsc{gf}_{\text{ante}}$ is the grammatical function whose value is the potential antecedent of the anaphor, labeled f in (44) and referred to as $\rightarrow$ in (43). The f-structure labeled c in (44) is a coargument of $\textsc{gf}_{\text{ante}}$, and is given the name %COARG in the first constraint in (43). According to the second constraint, there is a path[5] GF* through c leading to the f-structure p of the anaphor; in other words, c is the coargument of f which contains the anaphor. We can now require the potential antecedent f to be more prominent than its coargument c by specifying a particular definition for the relation PROMINENT.

(44)
$$\begin{bmatrix} \textsc{gf}_{\text{ante}} & f[\ ] \\ \textsc{gf} & c[\ \ldots\ p[\ ]] \end{bmatrix}$$

For example, we can impose a prominence constraint based on the grammatical function hierarchy by replacing the PROMINENT in (43) with the relation GF-OUTRANKS, which holds between arguments of the same predicate:

(45) GF-OUTRANKS(f_1, f_2) if and only if f_1 outranks f_2 on the grammatical function hierarchy.

We can then define the template GF-PROMINENT as encoding exactly this set of constraints.

(46) Definition of the template GF-PROMINENT:

$$\textsc{gf-prominent} \equiv \begin{array}{l} \%\textsc{coarg} = (\leftarrow \textsc{gf}) \\ (\%\textsc{coarg}\ \textsc{gf}^*) = \uparrow \\ \textsc{gf-outranks}(\rightarrow, \%\textsc{coarg}) \end{array}$$

[5] If the anaphor and its potential antecedent are coarguments, the path GF* is empty, and c and p are the same f-structure.

And we can state the binding conditions on *him* by means of the expression in (47), which uses this template.

(47) Prominent elements in the coargument domain:

$$((\underset{\neg(\rightarrow \text{PRED})}{\text{GF}^*}\ \text{GF}_{\text{pro}}\uparrow)\ \underset{@\text{GF-PROMINENT}}{\text{GF}_{\text{ante}}}\ )$$

The expression in (47) ranges over elements in the coargument domain which are higher on the grammatical function hierarchy than the f-structure of the anaphor: these are the f-structures which are relevant for the application of binding constraints. Argument structure and f-precedence prominence constraints are encoded similarly, by altering the definition of PROMINENT in (43).

4. ANAPHORA AND SEMANTIC COMPOSITION

We turn now to the central issue in the interpretation of anaphora: how the semantic relation is established between an anaphor and its antecedent. Within the glue semantics approach, several proposals have been made for the semantic treatment of anaphoric binding. The first proposal was made by Dalrymple et al. (1997), whose approach correctly handles the interactions of anaphora and quantification within the sentence; Asudeh (2004, 2012) adopts this approach, extending it to the treatment of resumptive pronouns (see Chapter 17, Section 6.4). However, that proposal only peripherally addresses issues that arise in analyzing intersentential anaphora – the interpretation of anaphors whose antecedents are not in the same sentence.

Subsequently, Crouch and van Genabith (1999) observed that the glue approach can also be harnessed to handle the context-changing potential of sentences. They propose that the linear logic glue language not only manages the dynamics of meaning composition within a sentence, but also manages *context resources* and *context update*. In their analysis, Crouch and van Genabith adopt an *e-type* treatment of anaphoric binding (Evans 1980), where descriptions of entities relevant in the discourse are constructed in the course of the derivation of the meaning of an utterance and are used in anaphora resolution both within the sentence and in subsequent discourse. Dalrymple (2001) follows Crouch and van Genabith (1999) in assuming that the glue approach not only accounts for resource-sensitive aspects of meaning assembly within sentences, but also manages contextual contributions in discourse interpretation. In contrast to their approach, however, Dalrymple (2001) provides a theory of coreference and anaphoric binding that is closer to Discourse Representation Theory (DRT: Kamp 1981; Kamp and Reyle 1993) and Dynamic Predicate Logic (Groenendijk and Stokhof 1991).

An alternative approach to using the glue language itself to manage contextual contributions across discourse is to combine glue with a meaning language which is more dynamic than standard predicate logic, and thus better able to handle the variability in coreference involved in anaphora. Kokkonidis (2005) proposes to pair glue expressions with meanings couched in a compositional version of DRT which is capable of dealing with anaphoric resolution. Haug (2014b) discusses anaphoric resolution in compositional DRT in detail, and develops a Partial version of Compositional DRT (PCDRT) which provides a clear separation of the semantic and pragmatic aspects of anaphora. Haug's proposals are further developed within the glue approach by Haug (2013) and Belyaev and Haug (2014), and in unpublished work by Mary Dalrymple, Dag Haug, and John Lowe. This is the approach that we adopt and build on in this book.

4.1. Anaphora in Context

It has long been clear that phrases like *David*, *someone*, or *a man* introduce new individuals into the context, and that these individuals can be referred to in later discourse. Karttunen (1976) was among the first to propose a formal theory of the ability of noun phrases to introduce a discourse referent representing some individual into the discourse context; discourse referents persist across the discourse and allow for the pragmatic resolution of anaphors in subsequent sentences to a discourse referent introduced at an earlier point. Karttunen's basic idea was elaborated and refined in the work of Heim (1982) on File Change Semantics and by Kamp (1981) in his work on Discourse Representation Theory (DRT). In both of these theories, certain kinds of phrases introduce discourse referents into the discourse context. Pronouns in subsequent discourse can take these phrases as antecedents and are resolved to the discourse referents that correspond to them.

For instance, part of the semantic contribution of sentences like *David arrived*, *I met David yesterday*, or *I am going to give the book to David* is to introduce a new discourse referent representing the individual David into the context. In the Discourse Representation Structure (DRS) for the sentence in (48), the proper name *David* introduces the discourse referent x_1.

(48) *David arrived.*

$$\begin{array}{|c|}\hline x_1 \\ \hline \mathit{David}(x_1) \\ \mathit{arrive}(x_1) \\ \hline \end{array}$$

In a DRS, discourse referents are listed in the "universe", the upper portion of the "box"; the discourse conditions, that is the truth-conditional requirements placed on the discourse referents, are represented in the lower portion of the box. In (48), there is only one discourse referent in the universe: x_1, introduced by *David*.

In our analysis, we assume the Partial Compositional DRT (PCDRT) approach of Haug (2014b), which differs from earlier versions of DRT in its treatment of anaphora. The standard DRT assumption is that a sentence containing a pronoun cannot be interpreted until the pronoun is resolved. This is problematic, as Haug points out: if a sentence with an unresolved pronoun is uninterpretable, the content of the sentence cannot play a role in determining how the pronoun is resolved. On the PCDRT view, anaphoric resolution is assumed to be part of the non-monotonic, pragmatic content of discourse. This also allows for the fact that as the hearer acquires additional information, it may become clear that the initial resolution for the pronoun was incorrect and must be revised.

In PCDRT, as in standard DRT, non-anaphoric phrases introduce discourse referents into the discourse context, as shown in (48).[6] Pronouns also introduce discourse referents, but unlike standard DRT, these are not directly resolved to their antecedents in the truth-conditional meaning representation. In the PCDRT-based DRS for the two sentences in (49), both the proper name and the pronoun introduce discourse referents, x_1 and x_2 respectively.

(49) *David arrived. He yawned.*

$$\begin{array}{|c|}\hline x_1\ \overline{x_2} \\ \hline \mathit{David}(x_1) \\ \mathit{arrive}(x_1) \\ \partial(\mathit{male}(x_2)) \\ \mathit{yawn}(x_2) \\ \hline \end{array}\ ,\ \mathcal{A}(x_2) = x_1$$

In (49), there are two discourse referents in the universe: x_1, introduced by the proper noun *David*, and x_2, introduced by the pronoun *he*. The referent introduced by the pronoun is marked with an overbar ($\overline{x_2}$), representing the fact that x_2 is a discourse referent whose reference must be resolved. The descriptive content of the anaphoric pronoun *he*, in this case simply the information that the discourse referent is male, is embedded under the presupposition operator, ∂ (Beaver 1992), representing the fact that this aspect of the meaning constrains the possibilities for anaphoric resolution. The presupposition connective ∂ maps $\partial(\phi)$ to true if ϕ is true and to the undefined truth value otherwise. In this example, the only available antecedent for x_2 is x_1, but in more complex examples there may be other ways to resolve the reference of x_2.

Anaphoric resolution is represented as a function, $\mathcal{A}$, from anaphoric discourse referents to their antecedents: in (49), the relation $\mathcal{A}$ holds between x_2 and x_1. All anaphoric discourse referents must obey the requirement in (50) for coreference with an accessible antecedent; otherwise, there is a truth value gap. In (50), s is a DRS state, x is an anaphoric discourse referent, and ν is an interpretation function which assigns an individual to each discourse referent in every state. Notice that x and its antecedent must both be defined in the same state s; this yields the usual restrictions on anaphoric accessibility, as in DRT. We often omit the superscript s on $\mathcal{A}$, but with the understanding that the anaphoric relation $\mathcal{A}$ is defined only between discourse referents in the same state s. As above, ∂ is the presupposition connective.

(50) Constraint on anaphoric discourse referents:

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[6] Of course, discourse referents can also be introduced by various kinds of phrases and can correspond to events, to plural individuals formed from the individuals relevant in the context, and so on; see Kamp and Reyle (1993) for discussion of these issues. Haug's (2014b) approach can also manage these aspects of context update; see Dalrymple et al. (2018) for discussion of these issues.

$\partial(\nu(s)(x) = \nu(s)(\mathcal{A}_s(x)))$

Every anaphoric discourse referent x must be identical to its antecedent $\mathcal{A}_s(x)$ in every state s, thus yielding coreference or, if $\mathcal{A}_s(x)$ is itself bound by an operator, covariation.

Haug (2014b, pages 493–497) defines $\mathcal{A}$ as a composite function, depending on a function $\mathcal{I}$ from discourse referents to syntactically accessible objects called 'indices': as shown in (51), $\mathcal{A}$ is the composition of the function from discourse referents to their indices, a function $\mathcal{R}$ from anaphor indices to antecedent indices, and the inverse function $\mathcal{I}^{-1}$ from indices to discourse referents.

(51) Definition of $\mathcal{A}$ (see Haug 2014b, p. 497, ex. 69):

$$\mathcal{A}_s(x) \equiv \mathcal{I}_s^{-1}(\mathcal{R}_s(\mathcal{I}_s(x)))$$

The core of pragmatic anaphora resolution is then the function $\mathcal{R}$, which maps indices to antecedent indices; crucially, as we will see, indices are accessible to syntactic representations and constraints. This allows us to keep the simple idea underlying the coindexation approach, namely that anaphoric relations are just relations between syntactic tokens, but without presupposing that the resolution actually takes place in the syntax. We often omit the subscript s on $\mathcal{R}$, as we do with $\mathcal{A}$.

We thus have the following set-up: indices, which are syntactically accessible, introduce discourse referents; by mapping from the discourse referent of an anaphor to its index, then from the anaphor index to the index of its antecedent, and finally from the antecedent index to the antecedent discourse referent, we obtain a mapping between the discourse referent of an anaphor and its antecedent discourse referent (in a particular state s; as stated above, we often omit specification of s to avoid clutter).

(52) $\mathcal{R}$ as a relation between indices:

$$\begin{tikzcd}
\text{antecedent disc. ref.} & & \text{anaphor disc. ref.} \arrow[ll, "\mathcal{A} = \mathcal{I}^{-1} \circ \mathcal{R} \circ \mathcal{I}"'] \arrow[d, "\mathcal{I}"] \\
\text{index1} \arrow[u, "\mathcal{I}^{-1}"] \arrow[rr, "\mathcal{R}"] & & \text{index2}
\end{tikzcd}$$

Since $\mathcal{A}$ is uniquely determined by $\mathcal{R}$, we can define constraints on $\mathcal{R}$ to capture the constraints of binding theory.

In the remainder of this chapter, we present a theory of semantic composition which produces representations like the one in (49) for a sequence of sentences in a discourse, and also incorporates a theory of anaphora resolution which allows for the expression of the anaphoric binding constraints discussed in Section 2.

4.2. Meaning and Context Update

As in standard DRT, PCDRT assumes that certain phrases introduce discourse referents into the context, and thus that the DRS is a representation of the context and the discourse referents it contains. As shown in (48), the DRS for the sentence *David arrived* includes the conditions $\mathit{David}(x_1)$ and $\mathit{arrive}(x_1)$, which are required to hold of the discourse referent x_1 introduced by the name *David*. The same observations can be made for indefinite noun phrases like *a man*. The sentence *A man arrived* introduces a new discourse referent into the context, which can be used to resolve a pronoun in subsequent discourse. In Chapter 8, Section 4.1.4, we proposed the meaning $a(x, \mathit{man}(x), \mathit{arrive}(x))$ for the sentence *A man arrived*. The components of this meaning $\mathit{man}(x)$ and $\mathit{arrive}(x)$ also play a role in the DRS for the sentence, which asserts the existence of some individual x_1 who is a man and who arrived.

(53) *A man arrived.*

$$\begin{array}{|c|}\hline x_1 \\ \hline \mathit{man}(x_1) \\ \mathit{arrive}(x_1) \\ \hline \end{array}$$

If the discourse starting with the sentence in (53) continues with the sentence *He yawned*, we have Haug's (2014b) PCDRT representation in (54). The discourse referent x_2 for the pronoun *he* is anaphoric, as indicated by the overbar. We assume that it takes as its antecedent the discourse referent x_1 for the phrase *a man*, as represented by the $\mathcal{A}$ relation:

(54) *A man arrived. He yawned.*

$$\begin{array}{|c|}\hline x_1\ \overline{x_2} \\ \hline \mathit{man}(x_1) \\ \mathit{arrive}(x_1) \\ \partial(\mathit{male}(x_2)) \\ \mathit{yawn}(x_2) \\ \hline \end{array}\ , \ \mathcal{A}(x_2) = x_1$$

As in standard DRT, quantifiers like *nobody* and *everyone* are different from proper names and indefinites in their effect on the context. They do not introduce new discourse referents into the wider discourse; instead, they effectively "trap" discourse referents and do not allow them to contribute to the global context. When a sentence like *Nobody arrived* or *Everyone arrived* is uttered, no discourse referents are made contextually available outside these structures:[7]

[7] The symbol ¬ in front of the sub-DRS in (55) is the negation symbol. On the treatment of negative quantifiers such as *nobody* in DRT, see Corblin (1996).

(55) *Nobody arrived.*

$$\begin{array}{|c|}\hline \\ \hline \neg\begin{array}{|c|}\hline x_1 \\ \hline \mathit{person}(x_1) \\ \mathit{arrive}(x_1) \\ \hline\end{array} \\ \hline\end{array}$$

(56) *Everyone arrived.*

$$\begin{array}{|c|}\hline \\ \hline \begin{array}{|c|}\hline x_1 \\ \hline \mathit{person}(x_1) \\ \hline\end{array} \Rightarrow \begin{array}{|c|}\hline \\ \hline \mathit{arrive}(x_1) \\ \hline\end{array} \\ \hline\end{array}$$

In these examples, the universe of the main discourse structure is empty. This explains the infelicity of the sentences in (57), as there are no discourse referents available in the main discourse structure to resolve pronouns in subsequent discourse.

(57) a. *Nobody arrived. *He yawned.*

b. *Everyone arrived. *He yawned.*

In fact, even a referent introduced by an indefinite in the scope of a quantifier like *nobody* or *everyone* or in the scope of negation is not assumed to persist (Karttunen 1976; Groenendijk and Stokhof 1991; Kamp and Reyle 1993). As shown in (58), the reading of a sentence like *Nobody saw a mouse* in which *a mouse* has narrow scope relative to the subject *Nobody* does not allow reference to a mouse in subsequent discourse:[8]

(58) *Nobody saw a mouse. *It squeaked.*

This observation is reflected in the fact that the universe of the main discourse structure for *Nobody saw a mouse* does not contain discourse markers that represent either a mouse or a person:

(59) *Nobody saw a mouse.*

$$\begin{array}{|c|}\hline \\ \hline \neg\begin{array}{|c|}\hline x_1\ x_2 \\ \hline \mathit{person}(x_1) \\ \mathit{see}(x_1, x_2) \\ \mathit{mouse}(x_2) \\ \hline\end{array} \\ \hline\end{array}$$

[8] For a brief discussion of quantifier scope, including narrow and wide scope readings, see Chapter 8, Section 4.1.4.

4.3. Anaphora and Meaning Assembly

Section 2 showed that constraints on anaphora resolution are defined in terms of the syntactic and semantic role of the antecedent relative to the anaphor. In this section we show how the proposals of Haug (2014b) can be used in a treatment of both intrasentential and intersentential anaphora.

As discussed in Section 4.1, Haug (2014b) proposes to represent the anaphor-antecedent relation by the function $\mathcal{A}$, mediated via the function $\mathcal{R}$ from anaphor indices to antecedent indices. We assign indices as the value of the INDEX attribute in semantic structure.[9] To make it clear which index corresponds to which discourse referent, we represent indices as numbers, and we use the same number (for instance, the number 1 in example 60) for an index and the discourse referent to which it corresponds. For example, in (60) we assume that the word *David* introduces the index 1, which appears as the value of the INDEX attribute in the semantic structure projected from the f-structure headed by *David*, and is related via the function $\mathcal{I}$ to the discourse referent x_1.

(60)
$$d\begin{bmatrix}\text{PRED} & \text{`David'}\end{bmatrix} \overset{\sigma}{\dashrightarrow} d_\sigma\begin{bmatrix}\text{INDEX} & 1\end{bmatrix} \quad \xleftarrow{\mathcal{I}} \quad \begin{array}{|c|}\hline x_1 \\ \hline \textit{David}(x_1) \\ \hline\end{array}$$

Similarly, the index introduced by a pronoun appears as the value of the INDEX attribute in the s-structure of the pronoun, and is related via the function $\mathcal{I}$ to the discourse referent of the pronoun. This is important in allowing the statement of syntactic constraints on anaphor-antecedent relations, since it allows the semantic relation between anaphors and their potential antecedents to be syntactically mediated and constrained.

4.3.1. Positive Binding Constraints

With the indices introduced by a pronoun and its potential antecedents represented as the value of the INDEX attribute at semantic structure, we can take advantage of the relation between semantic structure and f-structure to state the syntactic constraints on binding relations between anaphors and their antecedents discussed in Section 2. We make crucial use of the following familiar relations.

(61) If $\uparrow$ is the f-structure of the anaphor, then:

$\uparrow_\sigma$ is the semantic structure of the anaphor;

the value of ($\uparrow_\sigma$ INDEX) is the index contributed by the anaphor;

((GF^* GF_{pro} $\uparrow$) GF) represents the potential antecedents of the anaphor; and

[9] The INDEX attribute at f-structure and semantic structure have a very different status: the value of the f-structure INDEX feature is a syntactic agreement feature bundle specifying PERS, NUM, and GEND features (Chapter 2, Section 5.7.1), while the value of the semantic INDEX feature is a semantic index.

$(((\textsc{gf}^*\ \textsc{gf}_{\text{pro}} \uparrow)\ \textsc{gf})_{\sigma}\ \textsc{index})$ represents the indices contributed by the potential antecedents of the anaphor.

This means that we can constrain anaphoric resolution possibilities for an anaphor by referring to the INDEX values of the anaphor and of its potential antecedents. We assume that the appropriate prominence constraints are also imposed, as described in Section 3, though for the sake of simplicity of explanation we do not explicitly specify prominence constraints in this section.

As discussed in Section 2.1, positive binding constraints define the permissible syntactic relations between a pronoun and its antecedent. For instance, we have seen that the antecedent of the English reflexive pronoun *himself* must appear in the Minimal Complete Nucleus relative to the pronoun, that is, the minimal f-structure containing the pronoun and a SUBJ function. In the sentence *David compared Chris to himself*, there are two potential antecedents for *himself* in the Minimal Complete Nucleus: *David* and *Chris*. From a syntactic perspective, either of these antecedents may be chosen; here we assume a context in which *David* is chosen as the antecedent for *himself*. Example (62) illustrates a syntactically and semantically wellformed binding relation between *himself* and *David*:

(62) *David$_i$ compared Chris to himself$_i$.*

$$\left[\begin{array}{ll} \text{PRED} & \text{`COMPARE}\langle\text{SUBJ,OBJ,OBL}_{\text{TO}}\rangle\text{'} \\ \text{SUBJ} & d\left[\text{PRED}\ \ \text{`DAVID'}\right] \\ \text{OBJ} & \left[\text{PRED}\ \ \text{`CHRIS'}\right] \\ \text{OBL}_{\text{TO}} & p\left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{PRONTYPE} & \text{REFL} \\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3\\ \text{NUM} & \text{SG} \\ \text{GEND} & \text{M}\end{array}\right]\end{array}\right] \end{array}\right] \qquad \left.\begin{array}{l} d_{\sigma}\left[\text{INDEX}\ \ 1\right] \\ p_{\sigma}\left[\text{INDEX}\ \ 2\right]\end{array}\right\}\mathcal{R}$$

If we assume that p is the f-structure for *himself*, as in (62), the expression in (63) represents the set of permissible f-structure antecedents of *himself*, including *David* (the chosen antecedent) as well as *Chris* (a syntactically permitted antecedent, but not the one chosen in this context). The expression in (63) reflects the definition of the Minimal Complete Nucleus binding condition given in (15), according to which the f-structure path $\textsc{gf}^*$ delimiting the binding domain is not allowed to pass through an f-structure with a SUBJ function.

(63) F-commanding f-structures appearing in the Minimal Complete Nucleus relative to p:

$$((\underset{\neg(\rightarrow\ \textsc{subj})}{\textsc{gf}^*}\ \textsc{gf}_{\text{pro}}\ p)\ \ \textsc{gf})$$

We can now give a complete and explicit formulation of the positive Minimal Complete Nucleus binding constraint as it applies to the reflexive pronoun *himself*. The specification in (64) is a part of the lexical entry of *himself*, and constrains the $\mathcal{R}$ relation between the index of *himself* and the index of its antecedent:

(64) Positive Minimal Complete Nucleus binding constraint:

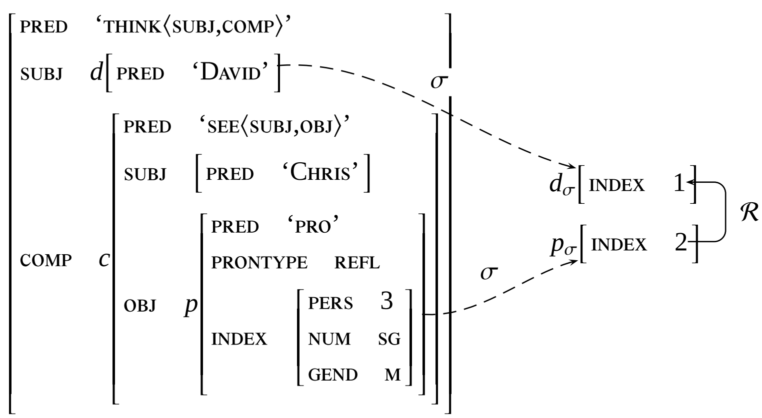
$$\mathcal{R}(\uparrow_\sigma \text{INDEX}) = (((\underset{\neg(\rightarrow\ \text{SUBJ})}{\text{GF}^*}\ \ \text{GF}_{\text{pro}}\uparrow)\ \ \text{GF})_\sigma\ \text{INDEX})$$

The equation in (64) requires the index of the antecedent of the pronoun, $\mathcal{R}(\uparrow_\sigma \text{INDEX})$, to appear as the value of INDEX in the s-structure of a syntactically permitted antecedent for the pronoun. In (62) this condition is met, and the binding relation is permitted.

Example (65) illustrates an impermissible binding relation:

(65) **David$_i$ thought that Chris had seen himself$_i$*.

Ill-formed binding relation violating (64):



The index for *David*, 1, cannot be chosen as the antecedent of the reflexive pronoun *himself*, and so cannot be the value of $\mathcal{R}(2)$, because the f-structure for *David* (labeled d) does not stand in a syntactically permissible antecedent relation to the pronoun f-structure p: the Minimal Complete Nucleus for the pronoun p is the COMP f-structure, labeled c in (65). In other words, the binding requirement in (64) is not satisfied when the antecedent *David* is chosen for the reflexive pronoun *himself* in (65).

4.3.2. Negative Binding Constraints

Section 2.2 discusses negative constraints, which rule out particular antecedents for a pronoun. In terms of the antecedency relation $\mathcal{R}$, negative constraints prevent syntactically impermissible antecedents from being chosen as the value of $\mathcal{R}$ for a pronoun.

For example, the pronoun *him* in (66) obeys the negative Coargument Condition: it may not corefer with its coargument *Chris,* but it may take *David* as its antecedent, since *David* is not a coargument, as the arrows representing the $\mathcal{R}$ relation indicate. For clarity, we represent the relation $\mathcal{R}$ by an arrow from the pronoun to its potential antecedent:

(66) *David*$_i$ *thought that Chris*$_j$ *had seen him*$_{i,*j}$.

Negative binding constraints are more complex to state than positive constraints, in that negative constraints cannot be stated simply as constraints on the antecedency relation $\mathcal{R}$. To see this, consider the following sentence:

(67) *David thought that he had seen him.*

The antecedent of *him* may not be *he*, since *him* and *he* are coarguments. However, as in (66), the antecedent of *him* may be *David*:

(68) *David*$_i$ *thought that he had seen him*$_i$.

Independently, *David* can serve as antecedent for *he* since, again, *David* does not stand in a coargument relation to *he*.

(69) *David*$_i$ *thought that he*$_i$ *had seen him.*

However, as observed by Wasow (1972), Lasnik (1976), and Higginbotham (1983), if *he* takes *David* as its antecedent, then *David* cannot also serve as antecedent for *him*, since in that case *he* and *him* would corefer, in violation of the requirement for a pronoun like *him* not to corefer with a coargument.

(70) *David*$_i$ *thought that he*$_i$ *had seen him*$_{*i}$.

It is not possible to disallow this unacceptable pattern simply by forbidding the anaphor-antecedent ($\mathcal{R}$) relation to hold between coarguments. Rather, we require *noncoreference* with coarguments: a pronoun which obeys the negative Coargument Condition is prevented from having as its antecedent not just its coarguments, but also any index which is related to one of its coarguments via an antecedent relation.

In order to impose the proper constraints, we define a function $\mathcal{R}^*$, a recursive version of $\mathcal{R}$. $\mathcal{R}^*$ follows the $\mathcal{R}$ path back from index to antecedent index, stopping only when it finds a index which does not have an antecedent.

(71) Definition of $\mathcal{R}^*$:

$$\mathcal{R}^*(x) = \begin{cases} x & \text{if } x \text{ does not have an antecedent as defined by the } \mathcal{R} \text{ relation} \\ \mathcal{R}^*(\mathcal{R}(x)) & \text{otherwise} \end{cases}$$

We can now formalize the negative constraint on *him* in the following way.

(72) Negative coargument condition:

$$\mathcal{R}^*(\uparrow_\sigma \mathrm{INDEX}) \neq \mathcal{R}^*(((\underset{\neg(\rightarrow\, \mathrm{PRED})}{\mathrm{GF}^*}\ \mathrm{GF}_{\mathrm{pro}} \uparrow)\ \mathrm{GF})_\sigma\ \mathrm{INDEX})$$

This complex constraint appears in the lexical entry of the pronoun *him*. Notice that the negation scopes over the disjunction over grammatical functions in the coargument domain, giving universal force: $\mathcal{R}^*(\uparrow_\sigma \mathrm{INDEX})$ may not be equal to $\mathcal{R}^*$ applied to *any* of the superior coarguments of $\uparrow$. We examine each part of this complex constraint in turn.

The constraint in (72) is repeated in (73), with the framed portion delimiting the noncoreference domain of the anaphor. The off-path constraint $\neg(\rightarrow \mathrm{PRED})$ defines the noncoreference domain as the Coargument Domain (compare example 17): the minimal f-structure containing a PRED.

(73) Coargument domain:

$$\mathcal{R}^*(\uparrow_\sigma \mathrm{INDEX}) \neq \mathcal{R}^*((\boxed{(\underset{\neg(\rightarrow\, \mathrm{PRED})}{\mathrm{GF}^*}\ \mathrm{GF}_{\mathrm{pro}} \uparrow)}\ \mathrm{GF})_\sigma\ \mathrm{INDEX})$$

The framed portion of the constraint in (74) picks out the semantic structures of the coarguments of the anaphor.[10]

(74) Semantic structures of the coarguments of the anaphor:

$$\mathcal{R}^*(\uparrow_\sigma \mathrm{INDEX}) \neq \mathcal{R}^*(\boxed{((\underset{\neg(\rightarrow\, \mathrm{PRED})}{\mathrm{GF}^*}\ \mathrm{GF}_{\mathrm{pro}} \uparrow)\ \mathrm{GF})_\sigma}\ \mathrm{INDEX})$$

Since indices appear as the value of the INDEX attribute in semantic structure, the framed portion of the constraint in (75) refers to the indices of the coarguments of the anaphor; these indices and any indices related to them via the $\mathcal{R}$ relation may not corefer with the anaphor or any of its antecedents.

(75) Indices of the coarguments of the anaphor:

$$\mathcal{R}^*(\uparrow_\sigma \mathrm{INDEX}) \neq \mathcal{R}^*\boxed{(((\underset{\neg(\rightarrow\, \mathrm{PRED})}{\mathrm{GF}^*}\ \mathrm{GF}_{\mathrm{pro}} \uparrow)\ \mathrm{GF})_\sigma\ \mathrm{INDEX})}$$

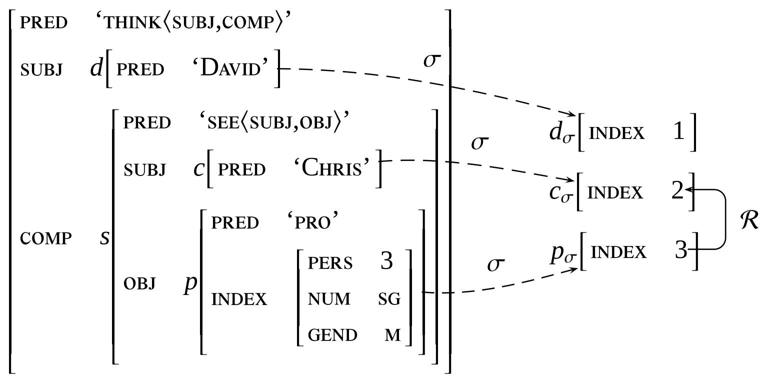
Thus, the constraint in (72) states that the discourse referent which is the antecedent (of the antecedent (of the antecedent...)) of the pronoun may not be identical with any coargument of the pronoun, or an antecedent (of an antecedent (of an antecedent...)) of any coargument of the pronoun. In the case of (70), this constraint produces the desired result: *David* is not an appropriate antecedent for *him* because *David* is the antecedent of *he*, and *he* is a coargument of *him*.

In the case of (76) and (77), this constraint prevents *him* from coreferring with *Chris* (76), but does not prevent *him* from coreferring with *David* (77), since *David* is neither a coargument of *him*, nor the antecedent of a coargument of *him*.

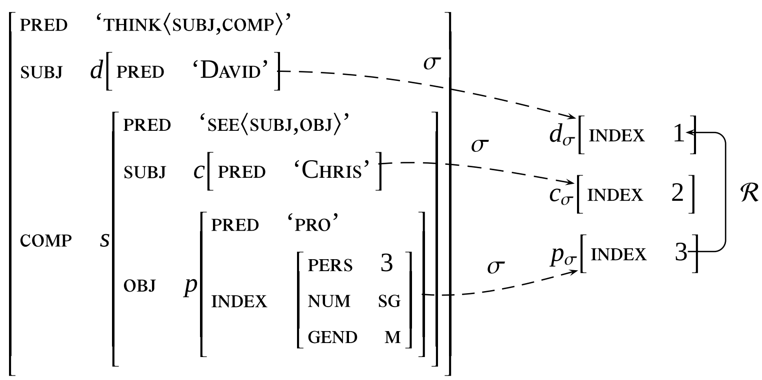
[10] Recall that we leave the prominence constraint implicit (see Section 3): the fully specified constraint would refer only to more prominent coarguments of the anaphor, not to all coarguments.

(76) **David thought that Chris*$_i$ *had seen him*$_i$.

Ill-formed binding relation:



(77) *David*$_i$ *thought that Chris had seen him*$_i$.



4.3.3. Intersentential Anaphora

There is no syntactic relation between f-structures that represent distinct clauses not related by coordination or subordination. That is, for the discourse

(78) *David arrived. He yawned.*

there is no syntactic relation between the f-structure for *David arrived* and the f-structure for *He yawned*, and therefore no syntactic relation between the f-structure for the anaphor *he* and the f-structure for its antecedent *David*. In such cases, the function $\mathcal{R}$ is not constrained by syntax. We assume that speakers have access to s-structures (and indices) from the preceding discourse, enabling them to make pragmatic connections between discourse referents belonging to different sentences and utterances. We can therefore use $\mathcal{R}$ for intersentential anaphora in exactly the same way as for intrasentential anaphora.

The first sentence of the discourse in (78) is *David arrived*, with the following f-structure, s-structure, and DRS:

(79) *David arrived.*

$$a\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{arrive}\langle\textsc{subj}\rangle\text{'}\\ \textsc{subj} & d\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{David}\text{'}\end{array}\right]\end{array}\right] \overset{\sigma}{\dashrightarrow} d_\sigma\left[\begin{array}{ll}\textsc{index} & 1\end{array}\right] \qquad \begin{array}{|c|}\hline x_1\\ \hline \textit{David}(x_1)\\ \textit{arrive}(x_1)\\ \hline\end{array}$$

The discourse continues with the sentence *He yawned*; the f-structure and s-structure for *He yawned* and the DRS for (78) are:

(80) *He yawned.*

$$y\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'}\\ \textsc{subj} & h\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{pro}\text{'}\\ \textsc{index} & \left[\begin{array}{ll}\textsc{pers} & 3\\ \textsc{num} & \textsc{sg}\\ \textsc{gend} & \textsc{m}\end{array}\right]\end{array}\right]\end{array}\right] \overset{\sigma}{\dashrightarrow} h_\sigma\left[\begin{array}{ll}\textsc{index} & 2\end{array}\right] \qquad \begin{array}{|c|}\hline x_1\ \overline{x_2}\\ \hline \textit{David}(x_1)\\ \textit{arrive}(x_1)\\ \partial(\textit{male}(x_2))\\ \textit{yawn}(x_2)\\ \hline\end{array}$$

Although there is no syntactic relation between the f-structure for *he* and the f-structure for its antecedent *David*, we assume that the discourse representation built up so far is available to the conversational participants, and that it is possible for the function $\mathcal{R}$ to relate the index 2 of the pronoun to the index 1 of its antecedent. Importantly, the negative constraint on pronouns given in (72) allows this, because the antecedent *David* is not coreferent with a more prominent syntactic coargument of the pronoun *he*. Example (81), repeated from (49), shows the resolved meaning representation for the discourse under discussion, with the anaphoric resolution function $\mathcal{R}$ relating the index for *he* to the index for *David*.

(81) *David arrived. He yawned.*

$$\begin{array}{|c|}\hline x_1\ \overline{x_2}\\ \hline \textit{David}(x_1)\\ \textit{arrive}(x_1)\\ \partial(\textit{male}(x_2))\\ \textit{yawn}(x_2)\\ \hline\end{array}\ ,\ \mathcal{R}(2) = 1$$

We now show how the DRS in (81) is produced from its component parts.

4.3.4. Discourse Representation Structures and Meaning Assembly

We assume this f-structure for the first sentence, *David arrived*:

(82) *David arrived.*

$$a\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{arrive}\langle\textsc{subj}\rangle\text{'}\\ \textsc{subj} & d\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{David}\text{'}\end{array}\right]\end{array}\right]$$

The lexical entries for *David* and *arrived* are given in (83); we type-raise *David*, treating it as a quantifier:

(83) *David* N $(\uparrow \text{PRED}) = \text{`D}{\small\text{AVID}}\text{'}$

$$\lambda P.\begin{array}{|c|}\hline x_1 \\ \hline \mathit{David}(x_1) \\ \hline \end{array} \oplus P(x_1) : \forall H.(\uparrow_\sigma \multimap H) \multimap H$$

arrived V $(\uparrow \text{PRED}) = \text{`ARRIVE}\langle \text{SUBJ} \rangle\text{'}$

$$\lambda x.\begin{array}{|c|}\hline \\ \hline \mathit{arrive}(x) \\ \hline \end{array} : (\uparrow \text{SUBJ})_\sigma \multimap \uparrow_\sigma$$

The symbol $\oplus$ represents the merge operation for combining DRSs by taking the union of the discourse referents in the universe and the union of the discourse conditions on the discourse referents. Instantiating the meaning constructors in (83) according to the labels in the f-structure in (82), we get:

(84) **[David]** $\lambda P.\begin{array}{|c|}\hline x_1 \\ \hline \mathit{David}(x_1) \\ \hline \end{array} \oplus P(x_1) \;:\; \forall H.(d_\sigma \multimap H) \multimap H$

[arrive] $\lambda x.\begin{array}{|c|}\hline \\ \hline \mathit{arrive}(x) \\ \hline \end{array} \;:\; d_\sigma \multimap a_\sigma$

These meaning constructors combine as follows:

(85) $\lambda P.\begin{array}{|c|}\hline x_1 \\ \hline \textsf{David}(x_1) \\ \hline\end{array} \oplus P(x_1) : \forall H.(d_\sigma \multimap H) \multimap H$

This is the meaning constructor **[David]**. On the glue side, if we find a semantic resource of the form $d_\sigma \multimap H$ for some semantic structure H, we consume that resource and produce a semantic resource for H. On the meaning side, we apply the function $\lambda P.\begin{array}{|c|}\hline x_1 \\ \hline \textsf{David}(x_1) \\ \hline\end{array} \oplus P(x_1)$ to the meaning associated with $d_\sigma \multimap H$.

$\lambda x.\begin{array}{|c|}\hline \\ \hline \textsf{arrive}(x) \\ \hline\end{array} : d_\sigma \multimap a_\sigma$

This is the meaning constructor **[arrive]**. On the glue side, it contributes an implicational resource $d_\sigma \multimap a_\sigma$, of exactly the form required by **[David]**. On the meaning side, it contributes a function from individuals x to a constraint requiring x to be an individual who arrived.

$[\lambda P.\begin{array}{|c|}\hline x_1 \\ \hline \textsf{David}(x_1) \\ \hline\end{array} \oplus P(x_1)](\lambda x.\begin{array}{|c|}\hline \\ \hline \textsf{arrive}(x) \\ \hline\end{array}) : a_\sigma$

By applying the meaning of **[David]** to the meaning of **[arrived]**, we have derived a meaning for the semantic structure a_σ. In the next step, we simplify this result by replacing all occurrences of P in the meaning contributed by **[David]** with the meaning contributed by **[arrive]**.

$\begin{array}{|c|}\hline x_1 \\ \hline \textsf{David}(x_1) \\ \hline\end{array} \oplus \lambda x.\begin{array}{|c|}\hline \\ \hline \textsf{arrive}(x) \\ \hline\end{array}(x_1) : a_\sigma$

We can now simplify again, by replacing all occurrences of x in the meaning of **[arrive]** with the discourse referent x_1.

$\begin{array}{|c|}\hline x_1 \\ \hline \textsf{David}(x_1) \\ \hline\end{array} \oplus \begin{array}{|c|}\hline \\ \hline \textsf{arrive}(x_1) \\ \hline\end{array} : a_\sigma$

The final simplification consists of merging the two DRSs connected by $\oplus$ into a single DRS, as required by the $\oplus$ merge operator.

$\begin{array}{|c|}\hline x_1 \\ \hline \textsf{David}(x_1) \\ \textsf{arrive}(x_1) \\ \hline\end{array} : a_\sigma$

We have produced the desired meaning for *David arrived*.

4.3.5. Context Update

In DRT terms, sentences are understood as context modifers: functions from a discourse context to a new, updated discourse context. Therefore, we must provide a way for the meaning of a sentence to update the context in which it appears. To accomplish this, we provide root sentences with an s-structure feature CONTEXT, whose value is associated with the DRS for the context in which the sentence appears. To model context update, we introduce a meaning constructor which consumes the input context for a root sentence and produces a new context which is relevant for subsequent discourse. We make the following assumptions:

(86) a. For a sequence of sentences $s1$ $s2$, where $s1$ immediately precedes $s2$, the value of the CONTEXT attribute of $s1$ is assigned as the initial value of the CONTEXT attribute of $s2$. If a sentence is the first sentence in a discourse and there is no preceding context, its CONTEXT value is initially associated with the null context.

b. Each sentence in a discourse contributes a context update meaning constructor which updates its initial CONTEXT to produce a new CONTEXT which can be further updated in subsequent discourse.

We begin our discussion of context update with an analysis of (78), in which the sentence *David arrived* is the first sentence. In this circumstance, we associate the value of the CONTEXT attribute of *David arrived* as the initial sentence in the discourse with the null context, represented as a DRS with an empty universe and no conditions. This is shown in (87) for the s-structure a_σ for the sentence *David arrived*.

(87) $\begin{array}{|c|}\hline \\ \hline \\ \hline\end{array} : (a_\sigma\ \textsc{context})$

Since sentences in DRT are treated as context modifiers, we associate root clauses with a meaning constructor enforcing modification of the current context. This is shown in (88).

(88) Context update meaning constructor:

$\lambda P.\lambda Q.P \oplus Q : \uparrow_\sigma \multimap (\uparrow_\sigma\ \textsc{context}) \multimap (\uparrow_\sigma\ \textsc{context})$

This meaning constructor consumes the meaning resource $\uparrow_\sigma$ of the root sentence to produce a modifier of its context. For the sentence *David arrived*, the up arrow $\uparrow$ in (88) is instantiated to a, as shown in (89a). Combining the context update meaning constructor in (89a) and the meaning of *David arrived* given in the last line of (85), repeated in (89b), produces the meaning constructor in (89c).

(89) a. $\lambda P.\lambda Q.P \oplus Q : a_\sigma \multimap (a_\sigma\ \textsc{context}) \multimap (a_\sigma\ \textsc{context})$

b. $\begin{array}{|c|}\hline x_1 \\ \hline \mathit{David}(x_1) \\ \mathit{arrive}(x_1) \\ \hline\end{array} : a_\sigma$

$$\text{c.}\quad \lambda Q.\begin{array}{|c|}\hline x_1 \\ \hline \mathit{David}(x_1) \\ \mathit{arrive}(x_1) \\ \hline \end{array} \oplus Q : (a_\sigma\ \text{CONTEXT}) \multimap (a_\sigma\ \text{CONTEXT})$$

Note that the meaning constructor in (89c) has the form of a context modifier (Chapter 13), consuming the meaning of the context of a sentence and producing an updated context meaning.

We now combine the meaning constructor in (89c) – which updates the input context with the meaning of the current sentence *David arrived* – with the input context in (87) representing the null context, since *David arrived* is the first sentence in the discourse. This produces the updated discourse context in (90), incorporating the effect of the sentence *David arrived* on the null context.

(90) *David arrived.*

$$a\left[\begin{array}{ll} \text{PRED} & \text{`ARRIVE}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`DAVID'}\end{array}\right] \end{array}\right] \qquad \begin{array}{|c|}\hline x_1 \\ \hline \mathit{David}(x_1) \\ \mathit{arrive}(x_1) \\ \hline \end{array} : (a_\sigma\ \text{CONTEXT})$$

4.3.6. Anaphora: Combining Clauses

In the discourse *David arrived. He yawned.*, the meaning derived in (90) for *David arrived* provides the context in which the sentence *He yawned* is evaluated.

(91) *He yawned.*

$$y\left[\begin{array}{ll} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & h\left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\end{array}\right] \end{array}\right]$$

The meaning constructors for *he* and *yawned* are:

(92) **[he]** $\lambda P.\begin{array}{|c|}\hline \overline{x_1} \\ \hline \partial(\mathit{male}(x_1)) \\ \hline \end{array} \oplus P(x_1) \ :\ \forall H.(h_\sigma \multimap H) \multimap H$

[yawn] $\lambda x.\begin{array}{|c|}\hline \\ \hline \mathit{yawn}(x) \\ \hline \end{array} \ :\ h_\sigma \multimap y_\sigma$

The meaning constructor for *he* differs from the one for *David* in only two ways. First, the discourse referent $\overline{x_1}$ is marked as an anaphoric discourse referent, as indicated by the overbar. This means that the discourse in which this referent appears can only be evaluated for truth in the context of an anaphoric resolution function $\mathcal{R}$. Secondly, the condition requiring $\overline{x_1}$ to be male is in the scope of the presupposition operator ∂. The meaning constructor for *yawn* differs from the one for *arrive* only in referring to an act of yawning rather than to an act of arriving.

Combining these meaning constructors along the same lines as in (85) produces the meaning in (93) for the sentence *He yawned*:

(93) *He yawned.*

$$\begin{array}{|c|}\hline \overline{x_1} \\ \hline \partial(\mathit{male}(x_1)) \\ \mathit{yawn}(x_1) \\ \hline \end{array} : y_\sigma$$

Since *He yawned* is a root sentence like *David arrived*, it also contributes the meaning constructor in (88), reflecting its role as a context modifier. Combining the meaning constructor in (93) with the meaning constructor in (88) produces the meaning constructor in (94), which requires the sentence to modify the context in which it appears.

(94) $$\lambda Q. \begin{array}{|c|}\hline \overline{x_1} \\ \hline \partial(\mathit{male}(x_1)) \\ \mathit{yawn}(x_1) \\ \hline \end{array} \oplus Q : (y_\sigma\ \textsc{context}) \multimap (y_\sigma\ \textsc{context})$$

The discourse context for the sentence *He yawned* is the context inherited from the previous sentence *David arrived*, shown in (90); that is, the initial CONTEXT value of the sentence *He yawned* is the same as the CONTEXT value of *David arrived*. Thus, (y_σ CONTEXT) is initially associated with the same CONTEXT as in (90).

(95) $$\begin{array}{|c|}\hline x_1 \\ \hline \mathit{David}(x_1) \\ \mathit{arrive}(x_1) \\ \hline \end{array} : (y_\sigma\ \textsc{context})$$

The meaning constructor in (95) must combine with the meaning constructor in (94) to update this context. When DRSs are combined, their discourse referents may have to be renumbered to prevent a clash; see Haug (2014b) for discussion of this point. Linear precedence determines which discourse referents are renumbered: referents introduced earlier in the discourse retain their subscript. In this example, then, $\overline{x_1}$ in the meaning for *He yawned* must be renumbered as $\overline{x_2}$ when its DRS is composed with the DRS for *David arrived*, since a discourse referent x_1 is already present. The result is:

(96) $$\begin{array}{|c|}\hline x_1\ \overline{x_2} \\ \hline \mathit{David}(x_1) \\ \mathit{arrive}(x_1) \\ \partial(\mathit{male}(x_2)) \\ \mathit{yawn}(x_2) \\ \hline \end{array} : (y_\sigma\ \textsc{context})$$

This meaning constructor is semantically complete, but it is uninterpretable in the absence of an anaphoric resolution for $\overline{x_2}$. In this case, there is only one possible antecedent, and therefore there is only one possible resolution.

(97)
$$\begin{array}{|c|}\hline x_1\ \overline{x_2} \\ \hline \textit{David}(x_1) \\ \textit{arrive}(x_1) \\ \partial(\textit{male}(x_2)) \\ \textit{yawn}(x_2) \\ \hline \end{array} : (y_\sigma\ \textsc{context}), \quad \mathcal{R}(2) = 1$$

Note that anaphoric resolution does not remove discourse referents from the context, or restrict the extent to which a particular discourse referent may function as an antecedent to further anaphors. For example, if the discourse above is continued by the sentence *He fell asleep*, the fact that x_1 serves as the antecedent to x_2 (by virtue of the resolution $\mathcal{R}(2) = 1$) does not prevent either x_1 or x_2 from also serving as the antecedent to the discourse referent x_3 introduced by the new pronoun.

4.3.7. Indefinites in Context

Like a proper name, an indefinite noun phrase like *a man* or *someone* introduces a discourse referent into the context. The f-structure and DRS for the sentence *Someone arrived* are:

(98) *Someone arrived.*

$$a\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{arrive}\langle\textsc{subj}\rangle\text{’} \\ \textsc{subj} & s\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{someone}\text{’} \end{bmatrix} \end{bmatrix} \qquad \begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \textit{arrive}(x_1) \\ \hline \end{array} : a_\sigma$$

After this sentence is uttered, the context (the universe of the DRS) contains the discourse referent x_1 representing an individual who is a person and who arrived.

To derive this meaning, we assume this lexical entry for *someone*.

(99) *someone* N $(\uparrow \textsc{pred}) = \text{‘}\textsc{someone}\text{’}$

$$\lambda P. \begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \hline \end{array} \oplus P(x_1) : \forall H.(\uparrow_\sigma \multimap H) \multimap H$$

This is similar in form to the lexical entry for the type-raised proper name *David* in (83).

In the derivation of the meaning of *Someone arrived*, the premises in (100) are relevant.

(100) Meaning constructor premises for *Someone arrived*:

[arrive] $\lambda x. \begin{array}{|c|}\hline \ \\ \hline \textit{arrive}(x) \\ \hline \end{array} \ : \ s_\sigma \multimap a_\sigma$

[someone] $\lambda P. \begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \hline \end{array} \oplus P(x_1) \ : \ (s_\sigma \multimap a_\sigma) \multimap a_\sigma$

These meaning constructors combine in the way shown in (85) to produce the complete and coherent meaning in (101), as desired.

(101) **[someone]**, **[arrive]** $\vdash$ $\begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \textit{arrive}(x_1) \\ \hline \end{array} : a_\sigma$

As a context modifier, this meaning constructor combines with the context-update meaning constructor in (88) to modify its context. In our example, this sentence is uttered at the beginning of a discourse, and so it combines with the meaning constructor **[null-context]** given in (87) just as described for *David arrived* in the previous section. The result is an updated context for a_σ, which provides the input context for the next sentence in the discourse.

(102) $\begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \textit{arrive}(x_1) \\ \hline \end{array} : (a_\sigma\ \text{CONTEXT})$

4.3.8. Indefinites as Antecedents

The context made available by the sentence *Someone arrived* contains the discourse referent x_1, representing a person who arrived.

(103) *Someone arrived.*

$\begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \textit{arrive}(x_1) \\ \hline \end{array}$

Interpretation of the sentence *He yawned* in this context proceeds as described in Section 4.3.6, since the input context in the two situations is very similar. The f-structure, semantic structure, and meaning constructor for *He yawned* are:

(104) *He yawned.*

$y\left[\begin{array}{ll} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & h\left[\begin{array}{ll}\text{PRED} & \text{`HE'}\end{array}\right] \end{array}\right] \quad \begin{array}{|c|}\hline \overline{x_1} \\ \hline \partial(\textit{male}(x_1)) \\ \textit{yawn}(x_1) \\ \hline \end{array} : y_\sigma$

The meaning constructor premises in (105) are involved in the derivation of the meaning of the discourse *Someone arrived. He yawned.* as follows.

(105) Meaning constructor premises for *Someone arrived. He yawned.*

[null-context] $$\begin{array}{|c|}\hline \quad \\ \hline \quad \\ \hline\end{array} : (a_\sigma \text{ CONTEXT})$$

[someone-arrive] $$\begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \textit{arrive}(x_1) \\ \hline\end{array} : a_\sigma$$

[context-mod1] $$\lambda P.\lambda Q.P \oplus Q : a_\sigma \multimap (a_\sigma \text{ CONTEXT}) \multimap (a_\sigma \text{ CONTEXT})$$

[he-yawn] $$\begin{array}{|c|}\hline \overline{x_1} \\ \hline \partial(\textit{male}(x_1)) \\ \textit{yawn}(x_1) \\ \hline\end{array} : y_\sigma$$

[context-mod2] $$\lambda P.\lambda Q.P \oplus Q : y_\sigma \multimap (y_\sigma \text{ CONTEXT}) \multimap (y_\sigma \text{ CONTEXT})$$

We begin by combining the meaning constructor **[someone-arrive]** with the meaning constructor **[context-mod1]** to produce a context modifier. Since this sentence is the first sentence in the discourse, the resulting meaning constructor combines with **[null-context]** to produce a CONTEXT for *Someone arrived*.

(106) $$\begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \textit{arrive}(x_1) \\ \hline\end{array} : (a_\sigma \text{ CONTEXT})$$

We likewise combine the meaning constructor **[he-yawn]** with the meaning constructor **[context-mod2]** to produce the following context modifier.

(107) $$\lambda Q. \begin{array}{|c|}\hline \overline{x_1} \\ \hline \partial(\textit{male}(x_1)) \\ \textit{yawn}(x_1) \\ \hline\end{array} \oplus Q : (y_\sigma \text{ CONTEXT}) \multimap (y_\sigma \text{ CONTEXT})$$

As with our previous examples, the context to be modified, (y_σ CONTEXT), is inherited from the previous sentence, here *Someone arrived*. In other words, the context for *He yawned* is the one given in (106), and the initial value for (y_σ CONTEXT) is inherited from (a_σ CONTEXT). Combining these meaning constructors produces the complete, updated context in (108) for *He yawned*, and the meaning for the discourse as a whole.

(108) **[null-context]**, **[he-yawn]**, **[context-mod1]**, **[someone-arrive]**, **[context-mod2]** $\vdash$

$$\begin{array}{|c|}\hline x_1\ \overline{x_2} \\ \hline \textit{person}(x_1) \\ \textit{arrive}(x_1) \\ \partial(\textit{male}(x_2)) \\ \textit{yawn}(x_2) \\ \hline\end{array} : (y_\sigma \text{ CONTEXT})$$

Since each sentence introduces its own discourse referent, there must be two distinct discourse referents in the combined meaning for the discourse. Thus the referent labeled x_1 in the meaning **[he-yawn]** must be renumbered as x_2 in the DRS in (108) to avoid identity with the referent introduced by the meaning **[someone-arrive]**.

As with our previous example, since this meaning contains anaphoric discourse referents, it is uninterpretable in the absence of a resolution function. Since there is only one possible antecedent for the pronoun, the result is as follows.

(109)
$$\begin{array}{|c|}\hline x_1\ \overline{x_2} \\ \hline \textit{person}(x_1) \\ \textit{arrive}(x_1) \\ \partial(\textit{male}(x_2)) \\ \textit{yawn}(x_2) \\ \hline \end{array} : (y_\sigma\ \textsc{context}),\ \mathcal{R}(2) = 1$$

4.4. Context and Quantifiers

Indefinite phrases like *someone* or *a man* are treated differently from quantified noun phrases like *nobody* or *every woman* in Discourse Representation Theory, as they are in Dynamic Predicate Logic (Groenendijk and Stokhof 1991): as discussed in Section 4.1, quantified noun phrases do not introduce a discourse referent into the context. The f-structure and meaning constructor for the sentence *Nobody arrived* are:

(110) *Nobody arrived. (*He yawned.)*

$$a\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{arrive}\langle\textsc{subj}\rangle\text{’} \\ \textsc{subj} & n\left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{nobody}\text{’}\end{array}\right] \end{array}\right] \qquad \begin{array}{|c|}\hline \\ \hline \neg \begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \textit{arrive}(x_1) \\ \hline \end{array} \\ \hline \end{array} : a_\sigma$$

No discourse referent is available outside the scope of the negation after this sentence is uttered; this explains the infelicity of a continuation like *He yawned*, which requires an accessible antecedent for interpretation of its pronoun subject.

We assume the following lexical entry for the negative quantifier *nobody*:

(111) *nobody* N $(\uparrow \textsc{pred}) = \text{‘}\textsc{nobody}\text{’}$

$$\lambda P. \begin{array}{|c|}\hline \\ \hline \neg[\begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \hline \end{array} \oplus P(x_1)] \\ \hline \end{array} : \forall H.(\uparrow_\sigma \multimap H) \multimap H$$

Instantiating the meaning constructor in (111) according to the f-structure labels in (110), we have the instantiated meaning constructor in (112), labeled **[nobody]**.

(112) **[nobody]** $\lambda P.\begin{array}{|c|}\hline \\ \hline \neg[\begin{array}{|c|}\hline x_1 \\ \hline \mathit{person}(x_1) \\ \hline \end{array} \oplus P(x_1)] \\ \hline \end{array} : (n_\sigma \multimap a_\sigma) \multimap a_\sigma$

The crucial difference between this meaning constructor and the one for *someone* is that the discourse referent introduced and the condition placed upon it are embedded within a larger DRS, under the scope of the negation operator. This means that the contextual contribution of *nobody* is to leave the wider context (that is, the context outside the scope of the negative) unchanged. Thus, like the earlier proposal of Dalrymple et al. (1997), this analysis has the desirable property of correctly characterizing interactions between quantifier scope and bound anaphora: any pronouns bound by a quantifier like *everyone* or *nobody* must appear within the scope of the quantifier, since the discourse referent introduced by the quantifier is only available in contexts within its scope, not outside it.

For the sentence *Nobody arrived*, we assume these meaning constructor premises.

(113) Meaning constructor premises for *Nobody arrived*:

[arrive] $\lambda x.\begin{array}{|c|}\hline \\ \hline \mathit{arrive}(x) \\ \hline \end{array} : n_\sigma \multimap a_\sigma$

[nobody] $\lambda P.\begin{array}{|c|}\hline \\ \hline \neg[\begin{array}{|c|}\hline x_1 \\ \hline \mathit{person}(x_1) \\ \hline \end{array} \oplus P(x_1)] \\ \hline \end{array} : (n_\sigma \multimap a_\sigma) \multimap a_\sigma$

These premises combine to produce:

(114) **[nobody]**, **[arrive]** $\vdash \begin{array}{|c|}\hline \\ \hline \neg \begin{array}{|c|}\hline x_1 \\ \hline \mathit{person}(x_1) \\ \mathit{arrive}(x_1) \\ \hline \end{array} \\ \hline \end{array} : a_\sigma$

Next, we briefly examine the derivation of the meaning of the sentence *Nobody saw a mouse*. On the most accessible reading of this sentence, the indefinite *a mouse* appears inside the scope of the quantifier *nobody*, and does not contribute to the overall context. This accounts for the infelicity of a sentence like *It squeaked* in subsequent discourse.

(115) *Nobody saw a mouse. (*It squeaked.)*

$$s\left[\begin{array}{ll}\text{PRED} & \text{`SEE}\langle\text{SUBJ,OBJ}\rangle\text{'}\\ \text{SUBJ} & n\left[\begin{array}{ll}\text{PRED} & \text{`NOBODY'}\end{array}\right]\\ \text{OBJ} & m\left[\begin{array}{ll}\text{DEF} & -\\ \text{PRED} & \text{`MOUSE'}\end{array}\right]\end{array}\right] \qquad \begin{array}{|c|}\hline \\ \hline \neg\ \begin{array}{|c|}\hline x_1\ x_2\\ \hline \textit{person}(x_1)\\ \textit{mouse}(x_2)\\ \textit{see}(x_1,x_2)\\ \hline\end{array}\\ \hline\end{array} : s_\sigma$$

The derivation of this reading proceeds on the basis of the meaning constructors in (116), which have been instantiated according to the f-structure labels in (115).

(116) Meaning constructor premises for *Nobody saw a mouse*:

$$\textbf{[see]} \quad \lambda y.\lambda z.\begin{array}{|c|}\hline \\ \hline \textit{see}(y,z)\\ \hline\end{array} \ : \ n_\sigma\multimap(m_\sigma\multimap s_\sigma)$$

$$\textbf{[nobody]} \quad \lambda P.\begin{array}{|c|}\hline \\ \hline \neg[\begin{array}{|c|}\hline x_1\\ \hline \textit{person}(x_1)\\ \hline\end{array}\oplus P(x_1)]\\ \hline\end{array} \ : \ \forall H.(n_\sigma\multimap H)\multimap H$$

$$\textbf{[a]} \quad \lambda P.\lambda Q.[\begin{array}{|c|}\hline x_2\\ \hline \\ \hline\end{array}\oplus P(x_2)\oplus Q(x_2)] \ : \ \forall H.((m_\sigma\ \text{INDEX})\multimap(m_\sigma\ \text{RESTR}))\multimap(m_\sigma\multimap H)\multimap H$$

$$\textbf{[mouse]} \quad \lambda x.\begin{array}{|c|}\hline \\ \hline \textit{mouse}(x)\\ \hline\end{array} \ : \ (m_\sigma\ \text{INDEX})\multimap(m_\sigma\ \text{RESTR})$$

The premises **[a]** and **[mouse]** combine to produce the meaning constructor in (117), labeled **[a-mouse]**:[11]

(117) **[a-mouse]** $\lambda Q.\begin{array}{|c|}\hline x_2\\ \hline \textit{mouse}(x_2)\\ \hline\end{array}\oplus Q(x_2) : \forall H.(m_\sigma\multimap H)\multimap H$

Combining the premises labeled **[a-mouse]** and **[see]**, we have the meaning constructor labeled **[see-a-mouse]**.[12]

(118) **[see-a-mouse]** $\lambda y.\begin{array}{|c|}\hline x_2\\ \hline \textit{mouse}(x_2)\\ \textit{see}(y,x_2)\\ \hline\end{array} : n_\sigma\multimap s_\sigma$

We combine this meaning constructor with **[nobody]**, producing the meaning constructor labeled **[nobody-see-a-mouse]**.

[11] For a full discussion of how the meaning of a determiner like *a* or *every* combines with the meaning of a common noun like *mouse*, see Chapter 8, Section 8.2.

[12] For the sake of space, we omit the introduction and discharging of a hypothetical subject. For details, see Chapter 8, Section 8.1.5.

(119) **[nobody-see-a-mouse]** $\begin{array}{|c|}\hline \\ \hline \neg \begin{array}{|c|}\hline x_1 \; x_2 \\ \hline \mathit{person}(x_1) \\ \mathit{mouse}(x_2) \\ \mathit{see}(x_1, x_2) \\ \hline \end{array} \\ \hline \end{array} : s_\sigma$

This reading of the sentence makes no discourse referents available for anaphora resolution in subsequent discourse. Outside of a special context, it is difficult to get a wide scope reading for the indefinite, according to which there is a particular mouse that no one saw.

The quantifier *everyone* works in an entirely parallel way. We assume the following meaning constructor for *everyone*.

(120) $\lambda P. \begin{array}{|c|}\hline \\ \hline \begin{array}{|c|}\hline x_1 \\ \hline \mathit{person}(x_1) \\ \hline \end{array} \Rightarrow P(x_1) \\ \hline \end{array} : \forall H.(\uparrow_\sigma \multimap H) \multimap H$

For the sentence *Everyone saw a mouse*, two readings are readily available: the indefinite can take narrow scope, meaning that each person saw a (possibly different) mouse, or wide scope, meaning that there is a particular mouse which everybody saw.[13] Under the second reading, a discourse referent corresponding to *a mouse* is available for pronoun resolution in subsequent discourse. We assume the following f-structure:

(121) *Everyone saw a mouse.*

$$s\left[\begin{array}{ll} \text{PRED} & \text{`SEE}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{SUBJ} & e\left[\begin{array}{ll} \text{PRED} & \text{`EVERYONE'} \end{array}\right] \\ \text{OBJ} & m\left[\begin{array}{ll} \text{DEF} & - \\ \text{PRED} & \text{`MOUSE'} \end{array}\right] \end{array}\right]$$

The derivation of the narrow-scope indefinite reading of this sentence proceeds on the basis of the following meaning constructors, which have been instantiated according to the f-structure labels in (121).

[13] Meaning constructors and deductions of narrow and wide scope readings for quantifiers are discussed in Chapter 8, Section 8.1.5.

(122) Meaning constructor premises for *Everyone saw a mouse*:

[see] $\lambda x.\lambda y.\begin{array}{|c|}\hline \\ \hline \textit{see}(x,y) \\ \hline \end{array} \ : \ e_{\sigma} \multimap (m_{\sigma} \multimap s_{\sigma})$

[everyone] $\lambda P.\begin{array}{|c|}\hline \\ \hline \begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \hline \end{array} \Rightarrow P(x_1) \\ \hline \end{array} \ : \ \forall H.(e_{\sigma} \multimap H) \multimap H$

[a-mouse] $\lambda P.\begin{array}{|c|}\hline x_2 \\ \hline \textit{mouse}(x_2) \\ \hline \end{array} \oplus P(x_2) \ : \ \forall H.(m_{\sigma} \multimap H) \multimap H$

As before, we combine the premises labeled **[a-mouse]** and **[see]** to produce the meaning constructor **[see-a-mouse]**.

(123) **[see-a-mouse]** $\lambda y.\begin{array}{|c|}\hline x_2 \\ \hline \textit{mouse}(x_2) \\ \textit{see}(y, x_2) \\ \hline \end{array} : e_{\sigma} \multimap s_{\sigma}$

We combine this meaning constructor with **[everyone]**, producing the meaning constructor labeled **[everyone-see-a-mouse]**.

(124) **[everyone-see-a-mouse]** $\begin{array}{|c|}\hline \\ \hline \begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \hline \end{array} \Rightarrow \begin{array}{|c|}\hline x_2 \\ \hline \textit{mouse}(x_2) \\ \textit{see}(x_1, x_2) \\ \hline \end{array} \\ \hline \end{array} : s_{\sigma}$

As with the narrow scope reading of *nobody saw a mouse*, this makes no discourse referents available for anaphora resolution in subsequent discourse.

When the indefinite takes wide scope, a discourse referent corresponding to *a mouse* is available. Beginning with the premises in (122), we combine the premises labeled **[everyone]** and **[see]**, producing the meaning constructor labeled **[everyone-see]**.

(125) **[everyone-see]** $\lambda y.\begin{array}{|c|}\hline \\ \hline \begin{array}{|c|}\hline x_1 \\ \hline \textit{person}(x_1) \\ \hline \end{array} \Rightarrow \begin{array}{|c|}\hline \\ \hline \textit{see}(x_1, y) \\ \hline \end{array} \\ \hline \end{array} : m_{\sigma} \multimap s_{\sigma}$

Combining this meaning constructor with **[a-mouse]** produces the meaning constructor labeled **[everyone-see-a-mouse2]**.

(126) **[everyone-see-a-mouse2]** $$\begin{array}{|c|}\hline x_2 \\ \hline \mathit{mouse}(x_2) \\ \begin{array}{|c|}\hline x_1 \\ \hline \mathit{person}(x_1) \\ \hline \end{array} \Rightarrow \begin{array}{|c|}\hline \quad \\ \hline \mathit{see}(x_1, x_2) \\ \hline \end{array} \\ \\ \hline \end{array} : s_\sigma$$

We have shown that the glue approach is valuable not only in accounting for meaning contributions in the derivation of the meaning of a sentence, but also in managing contextual contributions across sentences in a discourse. The representation of context and the DRT-based glue-theoretic treatment of anaphora resolution is of crucial importance in our treatment of *anaphoric control* in Chapter 15. Elsewhere, however, when context and anaphora resolution are not relevant to the semantic issues we examine, we employ simpler representations using predicate logic. No loss of generality results from this simplification.

5. FURTHER READING AND RELATED ISSUES

Research on the syntax of anaphoric binding has revealed correlations between the morphological form of a pronoun and its binding properties (Faltz 1977; Pica 1987): monomorphemic pronouns tend to have different binding properties from polymorphemic pronouns, for example. Bresnan et al. (2016, Chapter 11) provide a discussion and analysis of this issue from an LFG perspective; see also Lødrup (2007, 2008a) and Rákosi (2009).

Bresnan (2001a) addresses issues of markedness and asymmetries in pronominal systems: for instance, many languages have both free pronouns and null or incorporated pronominals, but there are no languages that have incorporated pronouns but no free pronominal forms. Bresnan proposes an Optimality-Theoretic analysis explaining these and other asymmetries. On the basis of an inspection of a large sample of languages, Siewierska (2003) verifies and refines some of Bresnan's claims.

The semantics of a predicate can play a role in the acceptability and distribution of anaphoric arguments of the predicate. Park (2012) argues that reflexive requirements can be lexically specified for distinct groups of predicates, and can narrow down the choice of anaphor in cases of overlapping syntactic binding domains.

Analyses of anaphoric binding often concentrate primarily on reflexives and non-reflexive pronouns, and less on reciprocals and reciprocal binding; an important exception is the analysis of reciprocals in Icelandic, Malagasy, and Swahili by Hurst (2010, 2012).

It is sometimes controversial or unclear whether a particular form is a reflexive pronoun with its own semantic form or a marker indicating detransitivization: that is, that one of the arguments of a predicate has been suppressed. Grimshaw

(1982a) discusses the French reflexive clitic, arguing that it is not in fact a reflexive pronoun, but a marker indicating that the verb has been detransitivized. Alsina (1996) provides similar arguments for Romance clitics, and Patejuk and Przepiórkowski (2015) for the Polish word *się*. De Alencar and Kelling (2005) argue for the opposite view for German and Romance: that reflexive clitics are in fact reflexive pronouns which fill an argument position of the predicate. Sells et al. (1987) provide a very useful discussion of diagnostics for syntactic and semantic transitivity and detransitivization.

In this chapter, our discussion has covered pronouns whose antecedency conditions are syntactically defined, that is, statable in terms of f-structural properties such as the presence of a PRED or SUBJ. However, not all pronouns obey purely syntactic binding conditions. Antecedency conditions for some pronouns depend on information structural properties of the sentence or discourse; Culy (2000) discusses *topic anaphora*, distinguishing among anaphors that refer to the topic of the sentence, paragraph, or story, and Strahan (2009) discusses discourse constraints on anaphoric binding in Icelandic. Other conditions on pronoun antecedency are also found: a *logophoric pronoun* is one which is used to refer to "the author of a discourse or to a participant whose thoughts are reported" (Hagége 1974, translation by Stirling 1988). Culy et al. (1995) examine the pronominal systems of three Dogon languages and trace their evolution from a common ancestor, showing how logophoric pronouns can evolve in the course of language change. Bresnan et al. (2016, Chapter 11) discuss logophoricity and constraints on logophoric pronouns, and Haug (2013) discusses the role of logophoricity in constructions involving partial control (see Chapter 15, Section 6).

Related to systems of pronominal binding, coreference, and logophoricity are systems of *obviation* and *switch reference*, where certain antecedents are allowed or disallowed for anaphors in certain syntactic positions. Simpson and Bresnan (1983) analyze control and obviation in Warlpiri; their analysis is reviewed by Dalrymple (1993), who provides a reanalysis using inside-out functional uncertainty.

Our semantic analysis depends heavily on work by Dag Haug and colleagues on Partial Compositional Discourse Representation Theory (Haug 2013, 2014a,b; Belyaev and Haug 2014). Haug (2014b) provides a full overview of the theory, Belyaev and Haug (2014) discusses the treatment of correlatives (on which see also Chapter 17, Section 1.2), and Haug (2014a) discusses anaphoric control and bridging.

15

FUNCTIONAL AND ANAPHORIC CONTROL

This chapter explores the syntax and semantics of functional and anaphoric control, constructions in which either syntactic or lexical constraints require coreference between an argument of the matrix clause and an argument of a subordinate or modifying adjunct clause. In English, such cases include the classes of "equi" and "raising" verbs. Crosslinguistically, descriptions of such constructions involve reference to functional syntactic properties such as SUBJ, OBJ, and so on; therefore, the syntactic discussion in this chapter is primarily centered around the f-structures of functional and anaphoric control constructions.

The open grammatical functions XCOMP and XADJ and the closed function COMP were first introduced by Bresnan (1982a) in a pioneering study of clausal relations and complementation. Since then, there has been a wealth of work in LFG building on these proposals. In the following sections, we will review the major proposals within LFG for the syntactic and semantic treatment of functional and anaphoric control constructions.

1. OPEN COMPLEMENTS AND FUNCTIONAL CONTROL

As an illustration of functional control, we first examine "raising" verbs,[1] verbs like *seem*:

(1) *David seemed to yawn.*

Raising verbs are distinguished by the fact that the "raised" argument, the SUBJ *David* in (1), is not a semantic argument of the raising verb. In other words, raising verbs impose no semantic constraints on the raised argument. Notationally, this is indicated by the position of the raised argument outside of the angled brackets in the semantic form of the raising verb, as discussed in Chapter 2, Section 4.6.1:

(2) *David seemed to yawn.*

$$\begin{bmatrix} \text{PRED} & \text{`SEEM}\langle\text{XCOMP}\rangle\text{SUBJ'} \\ \text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{`DAVID'}\end{bmatrix} \\ \text{XCOMP} & \begin{bmatrix} \text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \end{bmatrix}\end{bmatrix}$$

(3) *David believed Chris to know the answer.*

$$\begin{bmatrix} \text{PRED} & \text{`BELIEVE}\langle\text{SUBJ,XCOMP}\rangle\text{OBJ'} \\ \text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{`DAVID'}\end{bmatrix} \\ \text{OBJ} & \begin{bmatrix}\text{PRED} & \text{`CHRIS'}\end{bmatrix} \\ \text{XCOMP} & \begin{bmatrix} \text{PRED} & \text{`KNOW}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{SUBJ} & \\ \text{OBJ} & \begin{bmatrix}\text{DEF} & + \\ \text{PRED} & \text{`ANSWER'}\end{bmatrix} \end{bmatrix}\end{bmatrix}$$

Raising verbs in English and other languages exemplify *functional control*. Functional control verbs require as an argument an open complement XCOMP (Chapter 2, Section 1.7). In (2), the SUBJ of the raising verb *functionally controls* the SUBJ of the subordinate XCOMP. This means that the SUBJ of the verb *seemed* is required to be the same f-structure as the SUBJ of the subordinate XCOMP, as indicated by the line connecting the two subject positions in (2); see Chapter 2, Section 4.3. Other raising verbs exhibit functional control by an OBJ, as shown in (3), where the OBJ of the matrix verb is the same as the SUBJ of the XCOMP.

[1] "Raising" verbs are so called because of their analysis in transformational grammar (Kiparsky and Kiparsky 1970; Postal 1974), in which the subject phrase of the subordinate clause was assumed to have raised, or moved up, from the subordinate clause to its final position in the matrix clause.

1.1. Evidence for Functional Control

In functional control analyses as seen in (2) and (3), in which the same argument is both an argument of the matrix verb and the SUBJ of the subordinate XCOMP, any syntactic restrictions that are imposed on the SUBJ in the subordinate clause must also hold for the "raised" argument, since the same f-structure is an argument in both the matrix and the subordinate clause.

As discussed in Chapter 2, Section 5.3, some English predicates require a semantically empty subject – an expletive subject – with a particular syntactic form. For example, the verb *rain* requires its subject to have the form *it*, not *there*:

(4) a. *It is raining.*

b. **There is raining.*

The f-structure for (4a) is:

(5)
$$\begin{bmatrix} \text{PRED} & \text{`RAIN}\langle\rangle\text{SUBJ'} \\ \text{SUBJ} & \begin{bmatrix} \text{FORM} & \text{IT} \end{bmatrix} \end{bmatrix}$$

In contrast, the verb *be* in the existential *there*-construction requires its subject to have the form *there*:

(6) *There is a problem.*

Since raising verbs impose no semantic constraints on their "raised" argument, we expect expletive arguments – arguments with no semantic content – to appear felicitously in raising constructions (Postal 1974; Bresnan 1982a,c). Syntactic requirements on the form of the "raised" argument must also be met in the functional control construction, since both matrix and subordinate clause requirements must be satisfied:

(7) a. *It seems to be raining.*

b. *There seems to be a problem.*

(8) a. *David believed it to be raining.*

b. *David believed there to be a problem.*

In (7) and (8), the "raised" argument/controller is not a semantic argument of either the matrix or the subordinate predicate; syntactic requirements imposed by the subordinate clause verb are satisfied, no semantic requirements are violated, and the examples are wellformed. The f-structures for (7a) and (8a) are:[2]

[2]On the FORM features in (9) see Chapter 2, Section 5.3.

(9) a. *<u>It</u> seems to be raining.*

$$\begin{bmatrix} \textsc{pred} & `\textsc{seem}\langle\textsc{xcomp}\rangle\textsc{subj}' \\ \textsc{subj} & \begin{bmatrix}\textsc{form} & \textsc{it}\end{bmatrix} \\ \textsc{xcomp} & \begin{bmatrix} \textsc{pred} & `\textsc{rain}\langle\rangle\textsc{subj}' \\ \textsc{subj} & \end{bmatrix} \end{bmatrix}$$

b. *David believed <u>it</u> to be raining.*

$$\begin{bmatrix} \textsc{pred} & `\textsc{believe}\langle\textsc{subj},\textsc{xcomp}\rangle\textsc{obj}' \\ \textsc{subj} & \begin{bmatrix}\textsc{pred} & `\textsc{David}'\end{bmatrix} \\ \textsc{obj} & \begin{bmatrix}\textsc{form} & \textsc{it}\end{bmatrix} \\ \textsc{xcomp} & \begin{bmatrix} \textsc{pred} & `\textsc{rain}\langle\rangle\textsc{subj}' \\ \textsc{subj} & \end{bmatrix} \end{bmatrix}$$

In English and many other languages, raising constructions like these are not limited to verbal predicates, but are also found with adjectival predicates. For example, the adjectival predicate *be likely* displays exactly the same behavior as subject-raising verbs like *seem*. Such predicates have a syntactically selected SUBJ argument which is not semantically selected, and is filled by the “raised” argument of the embedded complement:

(10) a. *It is likely to be raining.*

b. *David believed it to be likely to be raining.*

(11) a. *It is likely to be raining.*

$$\begin{bmatrix} \textsc{pred} & `\textsc{likely}\langle\textsc{xcomp}\rangle\textsc{subj}' \\ \textsc{subj} & \begin{bmatrix}\textsc{form} & \textsc{it}\end{bmatrix} \\ \textsc{xcomp} & \begin{bmatrix} \textsc{pred} & `\textsc{rain}\langle\rangle\textsc{subj}' \\ \textsc{subj} & \end{bmatrix} \end{bmatrix}$$

b. *David believed it to be likely to be raining.*

$$\begin{bmatrix} \text{PRED} & \text{`BELIEVE}\langle\text{SUBJ,XCOMP}\rangle\text{OBJ'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`DAVID'} \end{bmatrix} \\ \text{OBJ} & \begin{bmatrix} \text{FORM} & \text{IT} \end{bmatrix} \\ \text{XCOMP} & \begin{bmatrix} \text{PRED} & \text{`LIKELY}\langle\text{XCOMP}\rangle\text{SUBJ'} \\ \text{SUBJ} & \\ \text{XCOMP} & \begin{bmatrix} \text{PRED} & \text{`RAIN}\langle\rangle\text{SUBJ'} \\ \text{SUBJ} & \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Similarly, in languages in which predicates place requirements on the case of their arguments, any such requirements imposed by the subordinate predicate must likewise hold for the "raised" argument of the matrix predicate. Andrews (1982) discusses raising and functional control in Icelandic, exploring the behavior of "quirky case" verbs, verbs that lexically specify a particular case for their arguments. As discussed in Chapter 2, Section 2.1, Icelandic subjects of quirky case verbs can be marked with one of several cases, depending on requirements imposed by the verb.

(12) a. Accusative subject:

Drengina vantar mat.
boys.DEF.ACC lacks food.ACC

'The boys lack food.'

b. Dative subject:

Barninu batnaði veikin.
child.DEF.DAT recovered.from disease.DEF.NOM

'The child recovered from the disease.'

c. Genitive subject:

Verkjanna gætir ekki.
pains.DEF.GEN is.noticeable not

'The pains are not noticeable.'

Andrews shows that in a functional control construction, the case of a "raised" OBJ depends on the casemarking requirements on the SUBJ of the lower clause.

(13) a. Accusative "raised" object:

Hann telur mig (í barnaskap sínum) vanta peninga.
he believes me.ACC (in foolishness his) to.lack money.ACC

'He believes me (in his foolishness) to lack money.'

b. Dative “raised” object:

Hann telur barninu (í barnaskap sínum) hafa
he believes child.DEF.DAT (in foolishness his) to.have
batnað veikin.
recovered.from disease.DEF.NOM

‘He believes the child (in his foolishness) to have recovered from the disease.’

c. Genitive “raised” object:

Hann telur verkjanna (í barnaskap sínum) ekki gæta.
he believes pains.DEF.GEN (in foolishness his) not noticeable

‘He believes the pains (in his foolishness) not to be noticeable.’

The position of the parenthesized adjunct *í barnaskap sínum* ‘in his foolishness’, which is a matrix clause modifier, shows that the “raised” constituent does indeed appear as the OBJ of the matrix clause and not in the subordinate clause. Since this argument is also the SUBJ of the subordinate XCOMP, the constraints on casemarking that the subordinate XCOMP verb imposes on this argument must be met for the sentence to be wellformed. Andrews (1990a) and Zaenen and Maling (1990) provide more discussion of default case, quirky case, and raising verbs in Icelandic.

Jacobson (1990, 1992b) discusses some tests which may be taken to demonstrate the syntactic characteristics of the open complement XCOMP in English. First, VP complement drop is never possible for the open complement XCOMP:

(14) a. *[Did David really yawn?]*

He seemed $\left\{ \begin{array}{l} \textit{to (yawn).} \\ *\emptyset \end{array} \right.$

b. *[Did Chris really know the answer?]*

David believed him $\left\{ \begin{array}{l} \textit{to (know the answer).} \\ *\emptyset \quad \text{(wrong meaning)} \end{array} \right.$

Second, XCOMP is not among the syntactic categories that can appear in sentence-initial position in a long-distance dependency in English:

(15) a. **To yawn, David seemed.*

b. **To know the answer, David believed Chris.*

As we discuss further in Section 3.2, the closed complement COMP may behave differently in each of these respects.

1.2. Constituent Structure and Functional Constraints

We propose the following annotated phrase structure rule for functional control constructions in English (only details relevant to this construction are displayed):[3]

(16) $$\mathrm{V'} \longrightarrow \begin{pmatrix}\mathrm{V}\\ \uparrow = \downarrow\end{pmatrix} \begin{pmatrix}\mathrm{NP}\\ (\uparrow \textsc{obj}) = \downarrow\end{pmatrix} \begin{pmatrix}\mathrm{VP}\\ (\uparrow \textsc{xcomp}) = \downarrow\end{pmatrix}$$

This rule constrains the constituent structure of functional control constructions and the functional syntactic role of each constituent. Notice that the phrase structure rule does not specify the control relation between the matrix argument and the SUBJ of the XCOMP: the difference between verbs like *seemed*, whose SUBJ is also the SUBJ of its XCOMP, and *believed*, whose OBJ is the SUBJ of its XCOMP, is lexically specified by the raising verb, not given by constituent structure requirements.

The lexical entries for the English raising verbs *seemed* and *believed* contain the following syntactic information:

(17) *seemed* V $(\uparrow \textsc{pred}) = \text{`}\textsc{seem}\langle\textsc{xcomp}\rangle\textsc{subj}\text{'}$
$(\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj})$

(18) *believed* V $(\uparrow \textsc{pred}) = \text{`}\textsc{believe}\langle\textsc{subj},\textsc{xcomp}\rangle\textsc{obj}\text{'}$
$(\uparrow \textsc{obj}) = (\uparrow \textsc{xcomp subj})$

These lexical entries contain a *control equation* specifying the relation between a particular argument of the matrix clause and the SUBJ of the subordinate XCOMP. The control equations for the above verbs are:

(19) *seemed* $(\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj})$
believed $(\uparrow \textsc{obj}) = (\uparrow \textsc{xcomp subj})$

These lexical entries and phrase structure rules give rise to the c-structures and f-structures shown in (20) and (21) for examples (2)–(3). The theory of controller selection and how the control equation is determined will be discussed in Section 7.

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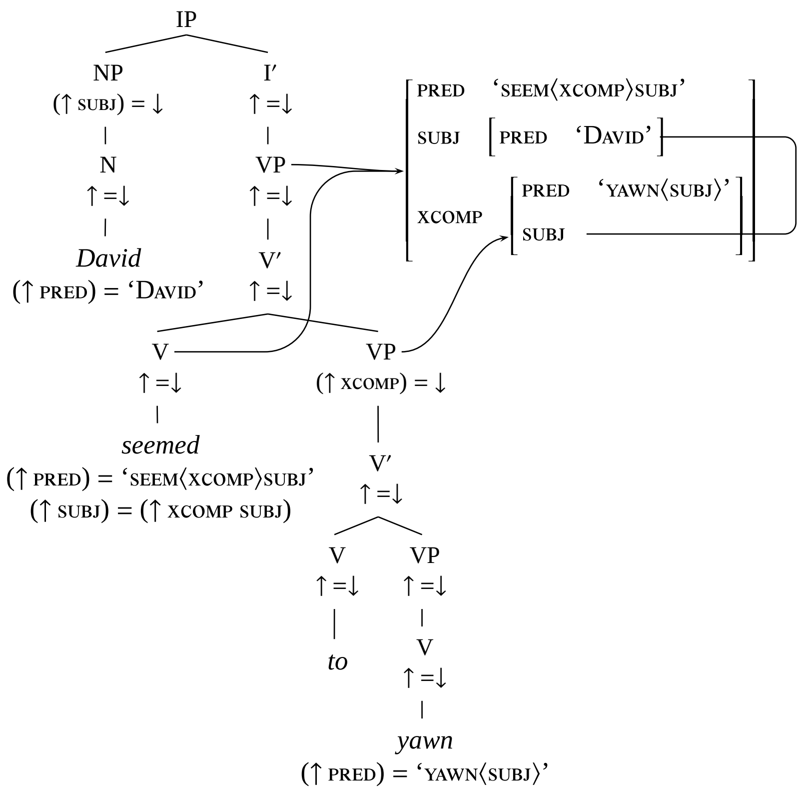
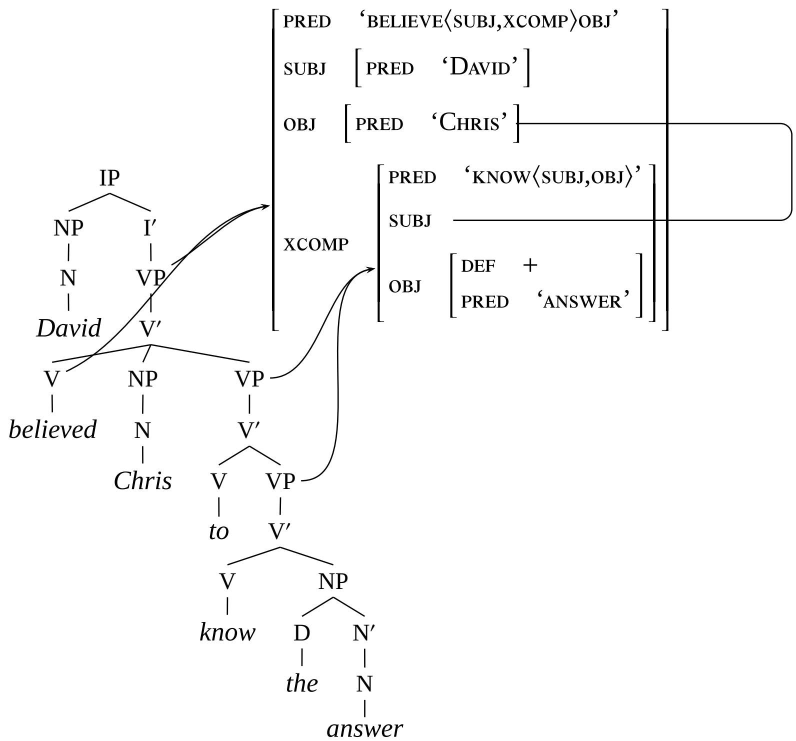
[3] With Bresnan et al. (2016), we classify the infinitival *to* complement as a VP, and we assume that the word *to* is head of the verbal projection. Falk (2001b) assumes a different c-structure for *to*-infinitives, arguing that *to* appears in C, as the head of CP.

(20) *David seemed to yawn.*



(21) *David believed Chris to know the answer.*



Raising predicates with *to*-infinitive complements are not the only structures in English which can be analyzed using XCOMP. Bresnan et al. (2016, Sections 12.1–12.2) discuss predicate complements such as the following:

(22) a. *Mary didn't sound ashamed of herself.*

b. *Louise struck me as a fool.*

c. *Jogging keeps Susan in a bad mood.*

d. *Linda will have your brother working again.*

In (22a), the underlined phrase is an AdjP; in (22b–c) the underlined phrases are PPs, and in (22d) the underlined phrase is a participial VP. All of the underlined phrases in (22) can be analyzed as XCOMP complements of their respective matrix verbs, as shown by Bresnan et al. (2016). Bresnan et al. also discuss interactions between raising and anaphoric binding in constructions such as these.

Falk (2005) notes that the vast majority of predicates which take XCOMP complements require those complements to be headed by a verbal predicate, and do not permit nominal, adjectival or prepositional complements. Falk argues that this is unexpected if all open complements have the same function XCOMP, since subcategorization is primarily functional, not categorial (Chapter 2, Section 3). Falk therefore argues for the differentiation of two additional open argument functions, $\textsc{xobj}_\theta$ and $\textsc{xobl}_\theta$, alongside XCOMP. Under this proposal, adjectival or nominal open complements are $\textsc{xobj}_\theta$, prepositional open complements are $\textsc{xobl}_\theta$, and XCOMP is restricted to verbal open complements. As discussed in Chapter 2, Section 1.7, the status of clausal complement functions, in particular COMP, is controversial; here we follow the traditional analysis of XCOMP as the grammatical function for all types of open complement.

1.3. Backward Control and Subsumption

Functional descriptions such as ($\uparrow$ SUBJ) = ($\uparrow$ XCOMP SUBJ), as in (19), specify a relation of *equality* between the values of two f-structures. In this case, the f-structure which serves as the value of ($\uparrow$ SUBJ) is the same f-structure which serves as the value of ($\uparrow$ XCOMP SUBJ). In contrast, Zaenen and Kaplan (2002) propose that some functional control relations are better analyzed in terms of *subsumption* (Chapter 6, Section 9.2), and this proposal is extended by Sells (2006b) to all functional control relations.

Zaenen and Kaplan (2002) contrast the ungrammaticality of the German sentence in (23a) with the grammaticality of (23b):

(23) a. * *[Ein Aussenseiter zu gewinnen] versuchte hier noch nie.*
An outsider to win tried here still never
'An outsider never tried to win here.'

b. *[Ein Aussenseiter zu gewinnen] schien hier eigentlich nie.*
An outsider to win seemed here actually never
'An outsider never actually seemed to win here.'

In both of these sentences, the four words preceding the finite verbs (*versuchte* and *schien* respectively) constitute a single phrase, meaning that the phrase *Ein Aussenseiter*, which is the subject of both verbs, appears within the embedded clause, rather than at the level of the matrix verb. This phenomenon is called *backward control*: rather than an argument of the matrix clause controlling an argument of the embedded clause, the control relation works 'backwards', an argument from the embedded clause controlling the missing argument position in the matrix clause (Polinsky and Potsdam 2002a,b, 2006). The f-structure assumed for example (23b) is:

(24)
$$\left[\begin{array}{ll} \text{PRED} & \text{`SEEM}\langle\text{SUBJ,XCOMP}\rangle\text{'} \\ \text{SUBJ} & \\ \text{XCOMP} & \left[\begin{array}{ll} \text{PRED} & \text{`WIN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`OUTSIDER'}\end{array}\right] \\ \text{ADJ} & \left\{ \begin{array}{l} \left[\begin{array}{ll}\text{PRED} & \text{`HERE'}\end{array}\right] \\ \left[\begin{array}{ll}\text{PRED} & \text{`ACTUALLY'}\end{array}\right] \\ \left[\begin{array}{ll}\text{PRED} & \text{`NEVER'}\end{array}\right] \end{array}\right\} \end{array}\right] \end{array}\right]$$

In (24), we represent the 'backward control' relation by depicting the f-structure for *ein Aussenseiter* 'an outsider' as the value of the XCOMP SUBJ, with a line connecting it to the matrix SUBJ. Importantly, this is done only for ease of exposition, and as an explicit indication that this example involves backward control. Zaenen and Kaplan (2002) analyze the verb *scheinen* 'seem' as requiring its SUBJ to be equal to its XCOMP's SUBJ; since the same f-structure appears as the value of both the SUBJ and the XCOMP SUBJ, there is no formal difference between this representation and one in which the 'outsider' f-structure is depicted as the value of the matrix SUBJ, with a line connecting it to the XCOMP SUBJ. For further discussion of this point, see Chapter 2, Section 4.3.

The question is why backward control is acceptable for the verb *scheinen* 'seem', but not for *versuchen* 'try'. Unlike the raising verb *seem*, the verb *try* is an "equi" verb. The analysis of equi verbs will be presented in more detail in Section 3, but at this point it is sufficient to note that Zaenen and Kaplan (2002) assume a functional control analysis for both raising and equi verbs in German. Crucially, Zaenen and Kaplan propose that equi verbs differ from raising verbs in that the control relation for raising verbs is stated in terms of equality, while the control relation for equi verbs is stated in terms of subsumption. They propose the following control relation for German *versuchen*:

(25) *versuchen* $(\uparrow \text{SUBJ}) \sqsubseteq (\uparrow \text{XCOMP SUBJ})$

The difference between equality and subsumption in this context can be thought of in terms of information flow. In the case of equality, information flow is bidirectional: any information specified for the embedded argument is automatically shared with the matrix argument, and vice versa, since they are equal. This allows the backward control relation observed for *scheinen* 'seem' in (23b), since a phrase filling the subordinate XCOMP SUBJ role is also required to fill the role of the main clause SUBJ. In the case of the subsumption relation required by the verb *versuchen* 'try', however, information flow is monodirectional: if $a \sqsubseteq b$, then any information specified for a must be shared with b, but information specified for b is not necessarily shared with a. With *versuchen*, then, if the shared argument appears in the matrix clause as the value of (↑ SUBJ), as desired, its PRED also appears as the value of (↑ XCOMP SUBJ), in much the same way as it would if the relation were one of equality. But if the shared argument appears in the embedded clause, as the value of (↑ XCOMP SUBJ), its PRED does not appear as the value of (↑ SUBJ), rendering the matrix f-structure incomplete. This models the fact that *versuchen* does not permit backward control: if the controller appears in the embedded clause, the matrix SUBJ position is empty, leading to an incomplete f-structure.

Sells (2006b) extends Zaenen and Kaplan's proposals in an analysis distinguishing forward and backward control, proposing that all functional control relations can be analyzed in terms of subsumption, and arguing that this provides a good model of the typology of control constructions. Sells argues that in German both raising and equi verbs involve subsumption; so, the functional description specifying the control relation for the raising verb *scheinen* 'seem' is exactly the same as that for *versuchen* 'try':

(26) *scheinen* (↑ SUBJ) $\sqsubseteq$ (↑ XCOMP SUBJ)

Why, then, is (23b) grammatical? Sells follows Berman (2003) in assuming that in German subjects do not need to contain a PRED feature, but may consist solely of agreement features if and only if they are non-thematic. The controller argument of raising predicates is, as we have seen above, not semantically selected by the raising predicate. Thus in the case of (23b), the lack of a semantically contentful (PRED-less) SUBJ at the matrix level does not lead to an incomplete f-structure. On the other hand, as we discuss in Section 4, the controller argument of an equi predicate is semantically selected, and so the f-structure is ill-formed if the matrix SUBJ lacks a PRED feature. This means that if control relations are stated in terms of subsumption, backward control is possible with raising predicates, but not with equi predicates.

In some languages, there are predicates which allow only backward control. Following work by Polinsky and Potsdam (2002b), Sells analyzes the Malagasy examples in (27) as 'forward control', with the controller overtly realized in the main clause, and the examples in (28) as 'backward control', with the controller overtly realized in the subordinate clause.

(27) Forward control:

a. *m-an-andrana [m-i-tondra ny fiara] Rabe*
PRS-ACTIVE-try [PRS-ACTIVE-drive the car] Rabe
'Rabe is trying to drive the car.'

b. *m-an-andrana Rabe [m-i-tondra ny fiara]*
PRS-ACTIVE-try Rabe [PRS-ACTIVE-drive the car]
'Rabe is trying to drive the car.'

(28) Backward control:

a. *m-an-omboka [m-i-tondra ny fiara Rabe]*
PRS-ACTIVE-begin PRS-ACTIVE-drive the car Rabe

'Rabe is beginning to drive the car.'

b. **m-an-omboka* *Rabe [m-i-tondra* *ny fiara]*
PRS-ACTIVE-begin Rabe [PRS-ACTIVE-drive the car]
'Rabe is beginning to drive the car.'

The ungrammaticality of (28b) is explained, following Polinsky and Potsdam (2002b), on the assumption that verbs such as *omboka* 'begin' in Malagasy display backward control: since the shared argument appears in the embedded clause, it cannot precede the embedded verb, unlike the shared argument in (27), which can either precede or follow the embedded verb since it is a part of the matrix clause. For constructions like these, in which only backward control is possible, Sells (2006b) proposes that the subsumption relation is stated the other way around:

(29) *omboka* $(\uparrow \text{XCOMP SUBJ}) \sqsubseteq (\uparrow \text{SUBJ})$

Since all of the constraints on the embedded subject also hold for the matrix subject, and since there is nothing else which can provide a SUBJ value for the XCOMP, this equation ensures that the controller must appear within the embedded clause.

Whether a comprehensive account of all functional control relations can be stated in terms of subsumption rather than equality is not clear. Haug (2011) discusses backward control phenomena in Ancient Greek, and concludes that equality, rather than subsumption, provides the most satisfying account (see also Haug 2017). Backward control in Indonesian is also discussed by Arka (2014).

2. RAISING VERBS AND SEMANTIC COMPOSITION

2.1. Semantics of Raising Verbs

The semantic contribution of raising verbs like *seem*, *appear*, and *tend* has been widely studied. We propose the representation in (30) for the sentence *David seemed to yawn*:

(30) *David seemed to yawn.*

$\mathit{seem}(\mathit{yawn}(\mathit{David}))$

In this example, the predicate *seem* holds of the proposition *yawn*(*David*), and the sentence has more or less the same meaning as the sentence *It seemed that David yawned*.

It has often been noted that scope ambiguities are available with the SUBJ argument of a subject raising verb like *seem* or *appear* and with the OBJ argument of an object raising verb like *believe* (May 1977; Williams 1983; Halvorsen 1983; Jacobson 1990): a raising verb allows a narrow scope reading for its "raised" argument. For example, a sentence like *Someone appeared to yawn* has two readings, a narrow scope reading paraphrasable as *It appeared that someone yawned* and a wide scope reading on which there is some person who appeared to yawn, as shown in (32).

(31) *Someone appeared to yawn.*

narrow scope interpretation = *It appeared that someone yawned (but perhaps no one is present).*
wide scope interpretation = *There is some person who appeared to yawn (but that person may not have yawned).*

This ambiguity depends on the scope of *someone*, whether it is inside or outside *appear*.

(32) *Someone appeared to yawn.*

Narrow scope: $\mathit{appear}(a(x, \mathit{person}(x), \mathit{yawn}(x)))$
Wide scope: $a(x, \mathit{person}(x), \mathit{appear}(\mathit{yawn}(x)))$

In the next section, we will see how both readings for this sentence are derived.

2.2. Raising Verbs and Meaning Assembly

The sentence *David seemed to yawn* is associated with the following f-structure and meaning constructor.

(33) *David seemed to yawn.*

$$s\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{seem}\langle\textsc{xcomp}\rangle\textsc{subj}\text{’} \\ \textsc{subj} & d\left[\begin{array}{ll}\textsc{pred} & \text{‘David’}\end{array}\right] \\ \textsc{xcomp} & y\left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{yawn}\langle\textsc{subj,obj}\rangle\text{’} \\ \textsc{subj} & \end{array}\right]\end{array}\right]$$

$\mathit{seem}(\mathit{yawn}(\mathit{David})) : s_\sigma$

Since our focus is not on anaphoric binding, we provide simple meaning constructors for (33) rather than the PCDRT-based meaning constructors presented in Chapter 14.

The presence of the SUBJ argument outside the angled brackets in the matrix PRED's semantic form in (33) indicates that the SUBJ of *seem* is not a semantic argument of the verb and that the sole semantic argument is the XCOMP. In keeping with this intuition, we follow Asudeh (2000, 2002a) in proposing the following lexical entry for the verb *seemed*:

(34) *seemed* V $(\uparrow \textsc{pred}) = \text{‘}\textsc{seem}\langle\textsc{xcomp}\rangle\textsc{subj}\text{’}$
$(\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj})$
$\lambda P.\mathit{seem}(P) : (\uparrow \textsc{xcomp})_\sigma \multimap \uparrow_\sigma$

The meaning constructor in the last line of this lexical entry requires an XCOMP argument. A meaning contribution corresponding to the SUBJ is not required, since the SUBJ meaning is not a semantic argument of *seem*. If the SUBJ contributes a meaning resource, it must be consumed by the XCOMP predicate for the sentence to be semantically complete and coherent.

We now instantiate the meaning constructor given in (34) according to the f-structure labels in (33). We also provide instantiated meaning constructors for the proper name *David* and the intransitive verb *yawn*.

(35) Meaning constructor premises for *David seemed to yawn*:

$$\begin{array}{lrl} \textbf{[seem]} & \lambda P.\mathit{seem}(P) : & y_\sigma \multimap s_\sigma \\ \textbf{[David]} & \mathit{David} : & d_\sigma \\ \textbf{[yawn]} & \lambda x.\mathit{yawn}(x) : & d_\sigma \multimap y_\sigma \end{array}$$

The meaning constructor labeled **[yawn]** requires a meaning for its subject, d_σ, to produce a meaning for y_σ. Thus, we first combine the meaning constructors **[David]** and **[yawn]** to produce the meaning constructor **[David-yawn]** for y_σ.

(36) **[David-yawn]** $\mathit{yawn}(\mathit{David}) : y_\sigma$

A meaning for y_σ is exactly what the meaning constructor **[seem]** requires, and a semantically complete and coherent meaning constructor for the sentence results.

(37) **[David-yawn]**, **[seem]** $\vdash \mathit{seem}(\mathit{yawn}(\mathit{David})) : s_\sigma$

Meaning deduction from the premises contributed by the sentence *Someone appeared to yawn* yields two different conclusions, since the example is ambiguous, with both a narrow and a wide scope reading, as shown in (31).

(38) *Someone appeared to yawn.*

$$a\left[\begin{array}{ll} \text{PRED} & \text{`APPEAR}\langle\text{XCOMP}\rangle\text{SUBJ'} \\ \text{SUBJ} & s\left[\begin{array}{ll}\text{PRED} & \text{`SOMEONE'}\end{array}\right] \\ \text{XCOMP} & y\left[\begin{array}{ll}\text{PRED} & \text{`YAWN}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \end{array}\right]\end{array}\right]$$

Narrow scope: $\mathit{appear}(a(x, \mathit{person}(x), \mathit{yawn}(x))) : a_\sigma$
Wide scope: $a(x, \mathit{person}(x), \mathit{appear}(\mathit{yawn}(x))) : a_\sigma$

The meaning constructor premises in (39) are relevant for this example. Again, since we are examining the semantics of raising verbs and are not concentrating on issues related to context update and anaphoric binding, we provide the simple meaning constructor for the indefinite quantifier *someone* which was discussed in Chapter 8, Section 8, rather than the PCDRT constructor discussed in Chapter 14, Section 4.3.7.

(39) Meaning constructor premises for *Someone appeared to yawn*:

$$\begin{array}{llcl}
\textbf{[appear]} & \lambda P.\mathit{appear}(P) & : & y_\sigma \multimap a_\sigma \\
\textbf{[someone]} & \lambda S.a(x, \mathit{person}(x), S(x)) & : & \forall H.[s_\sigma \multimap H] \multimap H \\
\textbf{[yawn]} & \lambda x.\mathit{yawn}(x) & : & s_\sigma \multimap y_\sigma
\end{array}$$

For the narrow scope reading, we note that the quantifier meaning constructor **[someone]** requires as its argument a resource of the form $s_\sigma \multimap H$ for some semantic structure H. The meaning constructor **[yawn]** provides such a resource. Combining **[someone]** and **[yawn]**, we have the meaning constructor labeled **[someone-yawn]**.

(40) **[someone-yawn]** $a(x, \mathit{person}(x), \mathit{yawn}(x)) : y_\sigma$

The meaning constructor in (40) provides a meaning resource y_σ, exactly what the meaning constructor labeled **[appear]** in (39) requires. Combining **[someone-yawn]** and **[appear]**, we obtain the semantically complete and coherent meaning constructor in (41), yielding the narrow scope reading:

(41) **[someone-yawn]**, **[appear]** $\vdash$ $\mathit{appear}(a(x, \mathit{person}(x), \mathit{yawn}(x))) : a_\sigma$

To derive the wide scope reading for the example, we make use of the abstraction rule given as (74) in Chapter 8. Recall that this rule permits the introduction of a hypothetical premise on the glue side, which is discharged at a later point in the deduction; on the meaning side, hypothetical premise discharge corresponds to abstracting over the variable introduced by the premise. For this example, we hypothesize the premise $x : [s_\sigma]$ in the first line.

(42)
$$\dfrac{\dfrac{\dfrac{x : [s_\sigma] \qquad \textbf{[yawn]}}{\mathit{yawn}(x) : y_\sigma} \qquad \textbf{[appear]}}{\mathit{appear}(\mathit{yawn}(x)) : a_\sigma}}{\textbf{[appear-yawn]} \quad \lambda x.\mathit{appear}(\mathit{yawn}(x)) : s_\sigma \multimap a_\sigma}$$

As shown in (42), we combine the hypothesized premise $x : [s_\sigma]$ with the premise **[yawn]**, producing the meaning constructor $\mathit{yawn}(x) : y_\sigma$. This meaning constructor provides the semantic resource y_σ required by **[appear]**. Combining these two meaning constructors, we produce the meaning constructor $\mathit{appear}(\mathit{yawn}(x)) : a_\sigma$. Finally, the hypothesized premise $x : [s_\sigma]$ is discharged in the last line of (42), producing the meaning constructor labeled **[appear-yawn]**: the variable x is abstracted over on the left-hand side, producing the function $\lambda x.\mathit{appear}(\mathit{yawn}(x))$, and the implicational meaning constructor $s_\sigma \multimap a_\sigma$ is produced on the right-hand side.

The meaning constructor **[appear-yawn]** provides a resource of the form $s_\sigma \multimap H$, which is what the quantifier **[someone]** requires; for this reading, the semantic structure a_σ is chosen to provide the scope meaning of the quantifier. Combining the meaning constructors **[someone]** and **[appear-yawn]**, we obtain the semantically complete and coherent meaning constructor in (43), which provides the wide scope reading for this example.

(43) **[appear-yawn]**, **[someone]** $\vdash$ $a(x, person(x), appear(yawn(x))) : a_\sigma$

2.3. Copy Raising

Copy raising is closely related to the 'standard' instances of raising discussed above, but differs from standard raising in interesting ways. Extensive investigation of the syntax and semantics of copy raising has been undertaken by Asudeh (2002b, 2004, 2005, 2012) and Asudeh and Toivonen (2006, 2007, 2012). These examples of copy raising are taken from Asudeh and Toivonen (2006):

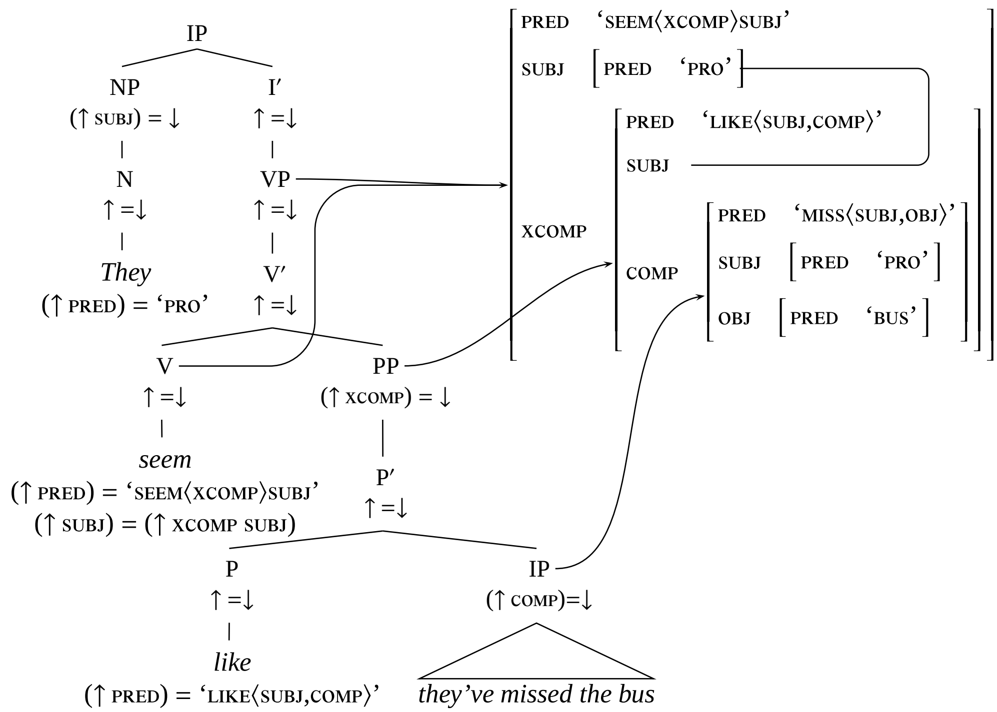
(44) a. *They seem like they've missed the bus.*

b. *John appears as if he is tired.*

Such sentences are parallel in many ways to sentences involving raising from infinitival complements: (44a) is similar to *They seem to have missed the bus*, and (44b) is parallel to *John appears to be tired*. The crucial similarity between the copy raising sentences and the standard raising sentences is that the subject of the matrix verb is not semantically selected, as is evident from sentences like *There seems like there's a problem*; the crucial difference is that there is a pronoun in the embedded clause corresponding to the controlled argument of the standard raising sentences (the 'copy'). Thus in contrast to standard raising, in copy raising there are two explicit noun phrases corresponding to a single semantically selected argument position. This leads to a semantic difficulty involving *resource surplus*: the pronoun subject of the embedded predication makes a contribution to the set of meaning resources available for semantic composition, but that contribution is neither required nor usable, because its role is already satisfied by the subject of the matrix predicate.

In terms of the syntactic analysis of copy raising, Asudeh and Toivonen propose that the apparent complementizers in English copy raising, e.g. *like* in (44a) and *as if* in (44b), are not in fact complementizers but rather prepositions which select for two arguments, a SUBJ and a closed complement COMP. The subject of the preposition is controlled by the subject of the matrix raising verb, just as in the standard raising examples, meaning that we can use exactly the same lexical entry and functional descriptions for the *seem* that occurs in copy raising as for the *seem* that occurs in standard raising.

(45) *They seem like they've missed the bus.*



In terms of semantic analysis, the main difficulty is the apparent duplication of argument resources, since in (44a) there are two instances of *they* corresponding to a meaning *seem*(*miss*(*they*, *bus*)), in which there is only one instance of the meaning of *they*. To account for this, Asudeh (2004) introduces a *manager resource*, lexically associated with copy raising verbs, which effectively serves to remove the superfluous pronoun meaning from the semantic composition. For reasons of space we do not provide an illustration here; see Asudeh (2004, 2005) for details.

3. CLOSED COMPLEMENTS AND ANAPHORIC CONTROL

Anaphoric control contrasts with functional control in several interlinked ways. The subordinate complement in an anaphoric control construction is the closed function COMP, not the open function XCOMP. Some constraints on the controller in an anaphoric control construction are similar to those in functional control, but the nature of the control is different: the relation in anaphoric control is semantically much closer to an anaphoric binding relation, and does not involve syntactic identity.

Anaphoric control constructions are of two types: obligatory anaphoric control and arbitrary anaphoric control (Bresnan 1982a; Zec 1987; Bresnan 2001c). In an obligatory anaphoric control construction, coreference is required between an argument of the matrix clause and the controlled argument in the subordinate clause. In contrast, in an arbitrary anaphoric control construction, no coreference constraints are imposed by the control verb. Instead, the controlled argument in the subordinate clause finds its referent in a way very similar to an ordinary pronoun, and split antecedents and syntactically remote controllers are possible.

3.1. Obligatory Anaphoric Control

Obligatory anaphoric control constructions were first examined in LFG by Bresnan (1982a), who showed that an anaphor in an anaphoric control construction may be assigned an antecedent by the rules of sentence grammar. Further exploration of anaphoric control in Bosnian/Croatian/Serbian was carried out by Zec (1987). In the following, we explore the syntax of obligatory anaphoric control; the semantics of these constructions will be discussed in Section 4.

In this work, we adopt an anaphoric control analysis of English equi verbs.[4] Under this analysis, English equi verbs exhibit obligatory anaphoric control of the SUBJ of a closed complement COMP:

(46) *David tried to leave.*

$$\begin{bmatrix} \text{PRED} & \text{`TRY}\langle\text{SUBJ,COMP}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{`David'}\end{bmatrix} \\ \text{COMP} & \begin{bmatrix} \text{PRED} & \text{`LEAVE}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{`PRO'}\end{bmatrix}\end{bmatrix}\end{bmatrix}$$

In (46), the SUBJ of the obligatory anaphoric control verb *tried* anaphorically controls the SUBJ of the COMP, and the sentence is interpreted as meaning that David tried to bring about a situation where David leaves. The controller in an anaphoric control construction can also be a matrix clause object if an appropriate matrix verb appears:

[4] "Equi" verbs are so called because of their participation in the "Equi-NP Deletion" transformation proposed for them by Postal (1970) and others in a transformational framework, in which an NP in subject position of the subordinate clause was assumed to be deleted under conditions of identity with an NP in the matrix clause.

(47) *David convinced Chris to leave.*

$$\left[\begin{array}{ll} \text{PRED} & \text{`CONVINCE}\langle\text{SUBJ,OBJ,COMP}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`DAVID'}\end{array}\right] \\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`CHRIS'}\end{array}\right] \\ \text{COMP} & \left[\begin{array}{ll} \text{PRED} & \text{`LEAVE}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\end{array}\right] \end{array}\right] \end{array}\right]$$

Here, the controller of the SUBJ of *leave* is the OBJ of the matrix verb, *Chris*, and the sentence means that David convinced Chris that Chris should leave.

It is not necessarily the case that if the matrix control verb has an OBJ, that argument must be the controller: with verbs such as *promise* it is possible for the matrix SUBJ to control the SUBJ of its COMP, even though there is also a matrix OBJ:

(48) *David promised Chris to leave.*

$$\left[\begin{array}{ll} \text{PRED} & \text{`PROMISE}\langle\text{SUBJ,OBJ,COMP}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`DAVID'}\end{array}\right] \\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`CHRIS'}\end{array}\right] \\ \text{COMP} & \left[\begin{array}{ll} \text{PRED} & \text{`LEAVE}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\end{array}\right] \end{array}\right] \end{array}\right]$$

Here, the controller of the SUBJ of *leave* is the SUBJ of the matrix verb, *David*, and the sentence means that David promised Chris that David would leave.[5] We discuss syntactic and semantic constraints on the controller in Section 7.

3.2. Anaphoric versus Functional Control

As we have already noted in passing in Section 1.3, obligatory anaphoric control is not the only possible way of analyzing English equi verbs; in fact, many authors assume a functional control analysis of equi verbs in English. It is clear that equi verbs differ from raising verbs in a number of ways, but to what extent those differences are reflected in the syntactic control structures assumed, and whether the differences are better explained in semantic terms, is less clear.

Perhaps the clearest evidence for obligatory anaphoric control as contrasted with functional control can be found in languages which show case mismatches between the controller and controlled position in equi constructions. In an anaphoric control construction, the anaphorically controlled SUBJ of the subordinate COMP is syntactically independent from the matrix controller, although the two

[5] This use of the verb *promise* appears to be dialect-specific, and is not available for all speakers.

are semantically related by an anaphoric binding relation. Thus, unlike the situation with functional control, we do not expect syntactic restrictions imposed on the controlled SUBJ of the COMP to be relevant for the matrix clause controller. As Andrews (1982) shows for anaphoric control in Icelandic, the case restrictions found in Icelandic functional control constructions are not found in constructions involving anaphoric control.

As the sentences in (12) show, subjects in Icelandic can bear a case that is idiosyncratically assigned by the verb. In constructions involving functional control, the case requirements of the subordinate clause verb must be satisfied, as shown in (13). In contrast, in anaphoric control constructions in Icelandic, case requirements of the subordinate clause verb do not apply to the matrix controller. Example (49a) shows that the Icelandic verb *vanta* 'lack' requires an accusative SUBJ; in (49b), the subject of the verb *vanta* 'lack' is interpreted as coreferent with the subject of the equi verb *vonast* 'hope'. The subject of the anaphoric control verb *vonast* 'hope' is marked with NOM case, not ACC, even though the subordinate verb *vanta* 'lack' requires its subject to be marked with ACC case:

(49) a. *Drengina vantar mat.*
boys.DEF.ACC lacks food.ACC
'The boys lack food.'

b. *Ég vonast til að vanta ekki efni í ritgerðina.*
I.NOM hope to to lack not material for thesis.DEF
'I hope to not lack material for the thesis.'

This contrasts with the situation with functional control, illustrated in (13), where the case specified by the subordinate clause verb must appear on the matrix subject.

Since English lacks such case marking, the evidence for a functional distinction between raising and equi verbs is less clear.[6] As discussed in Section 1.1 of this chapter, Jacobson (1990, 1992b) investigates certain syntactic differences between English raising and equi verbs. One such difference is VP complement drop: the VP complement of many equi predicates may be dropped, but this is impossible with raising predicates (see also 14):

(50) a. *[Did David really leave?] He tried.*

b. *[Will Chris leave?] If David can convince him.*

(51) a. *[Did David really leave?] He seemed* $\left\{\begin{array}{l} \textit{to (leave).} \\ *\emptyset \end{array}\right.$

b. *[Does Chris vote?] David believes him* $\left\{\begin{array}{l} \textit{to (vote).} \\ *\emptyset \end{array}\right.$

[6] Zaenen and Kaplan (2002) even suggest that case mismatches between controller and controllee do not necessitate an anaphoric control analysis, since sharing of the CASE feature can be managed by use of the restriction operator (Chapter 6, Section 9.4). Such an approach is technically possible, but does not result in a linguistically appealing analysis.

This is a lexically governed option, which is not possible for all equi verbs:

(52) a. *[Did David really leave?] He wanted* $\begin{cases} \textit{to (leave).} \\ *\emptyset \end{cases}$

One way of accounting for this difference is by reference to grammatical function: closed VP COMP arguments may be dropped where lexically licensed, but open VP XCOMP arguments may not be dropped. Alternatively, it may be possible to account for the difference by reference to the major semantic difference between raising and equi constructions: the controller in a raising construction is not semantically selected by the raising verb, whereas the controller in an equi construction is semantically selected by the equi verb. If the entire VP complement is dropped in a raising construction, there is no overt signal of a predicate which can semantically select for the controller. Thus in (51b), the only possible interpretation of *David believes him* involves the transitive, non-raising version of *believe*, in which the OBJ *is* semantically selected by the verb.

Evidence from topicalization is also unclear. Jacobson (1990, 1992b) claims that while the complement of a raising verb cannot appear at the beginning of the sentence, as shown in (15), examples in which the infinitival complement of an equi verb appears in initial position are marginally acceptable:

(53) a. *?To leave, David (at least) tried.*

b. *?To leave, David (at least) convinced Chris.*

In fact, these examples are not acceptable for all speakers. Nevertheless, there does seem to be a contrast between the examples with sentence-initial infinitives in (53) and those in (15). The relatively low acceptability of the examples in (53) may in part be due to the unsuitability of the infinitive in the pragmatic/information structure role associated with the sentence-initial phrase (Tracy Holloway King, p.c.).

In principle, then, equi verbs can be analyzed in terms of either functional or anaphoric control, and it is sometimes assumed that equi constructions as well as raising constructions in English involve functional control (see, for example, Bresnan 1982a, 2001c; Asudeh 2000, 2002a; Falk 2001b; Bresnan et al. 2016). However, the evidence presented above is consistent with the proposal that at least some English equi verbs in fact participate in obligatory anaphoric control. In the absence of unequivocal evidence in favor of the functional control analysis for English equi verbs, we adopt the obligatory anaphoric control analysis in this work. Falk (2001b) provides an illuminating discussion of the difference between anaphoric and functional control in equi constructions, though the conclusions he draws are different from those adopted here.

In other languages, more variation is found: some languages have two clearly distinct types of equi verb, some specifying anaphoric control and some specifying functional control. Kroeger (1993, Chapter 4) shows that Tagalog has two different types of equi constructions. The first type involves functional control of a subject argument in the complement clause:

(54) *nagpilit* *si-Maria-ng* *bigy-an* *ng-pera* *ni-Ben*
PRF.AV.insist.on NOM-Maria-COMP give-DAT GEN-money GEN-Ben
'Maria insisted on being given money by Ben.'

$$\left[\begin{array}{ll} \text{PRED} & \text{`INSIST}\langle\text{SUBJ,XCOMP}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`MARIA'}\end{array}\right] \\ \text{XCOMP} & \left[\begin{array}{ll} \text{PRED} & \text{`GIVE}\langle\text{SUBJ,OBJ,OBJ}_{\text{AGENT}}\rangle\text{'} \\ \text{SUBJ} & \\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`MONEY'}\end{array}\right] \\ \text{OBJ}_{\text{AGENT}} & \left[\begin{array}{ll}\text{PRED} & \text{`BEN'}\end{array}\right] \end{array}\right] \end{array}\right]$$

The second type involves anaphoric control of a term (possibly nonsubject) argument in the complement clause. In (55), the matrix subject *Maria* anaphorically controls the $\text{OBJ}_{\text{AGENT}}$ argument in the subordinate clause:

(55) *nagpilit* *si-Maria-ng* *bigy-an* *ng-pera* *si-Ben*
PRF.AV.insist.on NOM-Maria-COMP give-DAT GEN-money NOM-Ben
'Maria insisted on giving money to Ben.'

$$\left[\begin{array}{ll} \text{PRED} & \text{`INSIST}\langle\text{SUBJ,COMP}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`MARIA'}\end{array}\right] \\ \text{COMP} & \left[\begin{array}{ll} \text{PRED} & \text{`GIVE}\langle\text{SUBJ,OBJ,OBJ}_{\text{AGENT}}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`BEN'}\end{array}\right] \\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`MONEY'}\end{array}\right] \\ \text{OBJ}_{\text{AGENT}} & \left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\end{array}\right] \end{array}\right] \end{array}\right]$$

Thus, equi verbs that can specify either functional or anaphoric control can be found, even within a single language.

3.3. Constituent Structure and Functional Constraints

To analyze anaphoric control, we augment the phrase structure rule in (16) to allow for VP complement daughters bearing the COMP function:

(56)
$$\text{V}' \longrightarrow \begin{pmatrix} \text{V} \\ \uparrow = \downarrow \end{pmatrix} \begin{pmatrix} \text{NP} \\ (\uparrow \text{OBJ}) = \downarrow \end{pmatrix} \begin{pmatrix} \text{VP} \\ (\uparrow \{\text{XCOMP}|\text{COMP}\}) = \downarrow \end{pmatrix}$$

The rule in (56) differs from the one in (16) in allowing the VP daughter of V′ to bear either the XCOMP or the COMP function. There is no constituent structure distinction between VP complements that are functionally controlled, bearing the XCOMP function, and those that are anaphorically controlled and bear the COMP function; XCOMP and anaphorically controlled COMP appear in the same position relative to adverbs and direct objects, for example:

(57) a. *The students seem clearly to be intelligent.* (XCOMP)

b. *The students tried hard to be on time.* (COMP)

(58) a. *The students believed David to have left.* (XCOMP)

b. *The students convinced David to leave.* (COMP)

Thus, it is only the functional annotations on the rule that distinguish the two cases, and not the c-structure configuration.

We propose the following syntactic lexical entries for the English equi verbs *tried* and *convinced*:

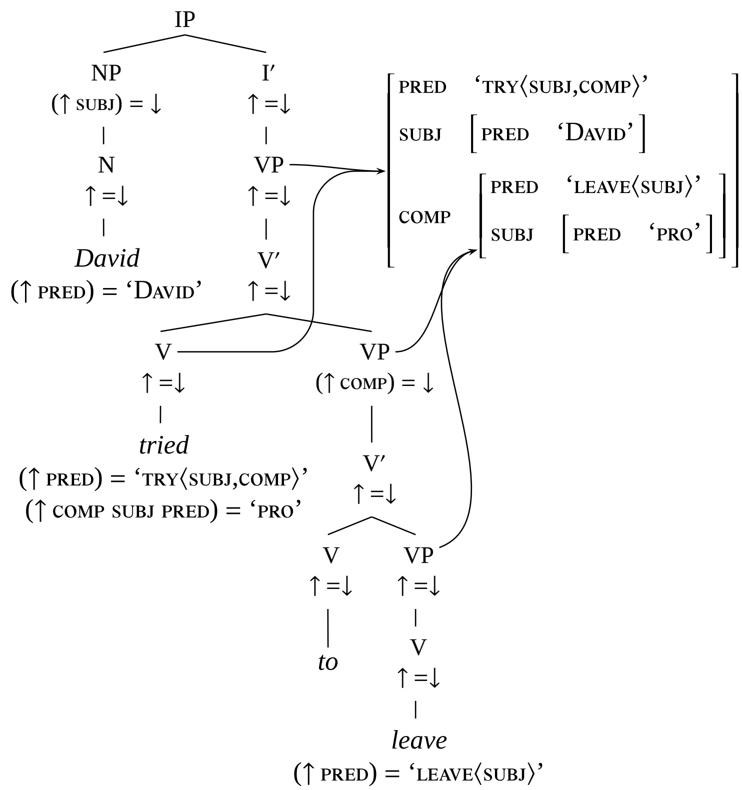
(59) *tried* V (↑ PRED) = 'TRY⟨SUBJ,COMP⟩'
(↑ COMP SUBJ PRED) = 'PRO'

(60) *convinced* V (↑ PRED) = 'CONVINCE⟨SUBJ,OBJ,COMP⟩'
(↑ COMP SUBJ PRED) = 'PRO'

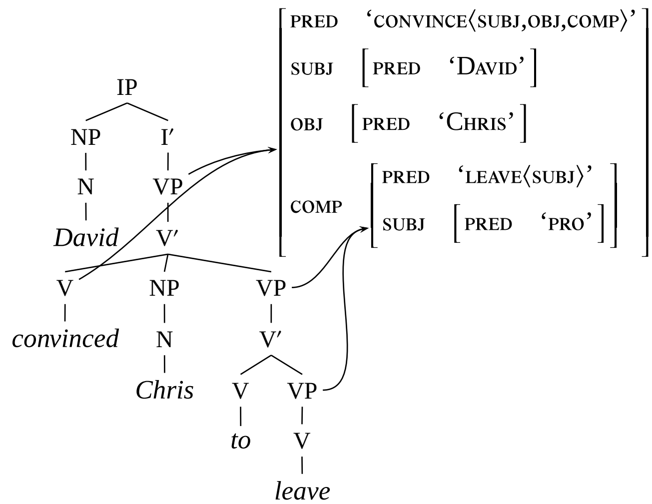
The last line in each of these lexical entries specifies a pronominal SUBJ for the subordinate COMP. In Section 4 we discuss how the anaphoric control relation is established between the matrix controller and the subordinate clause SUBJ.

These lexical entries, together with the annotated phrase structure rule in (56), give rise to the anaphoric control structures in (61) and (62).

(61) *David tried to leave.*



(62) *David convinced Chris to leave.*



4. EQUI VERBS AND SEMANTIC COMPOSITION

As discussed in Section 3.2 of this chapter, we adopt the position that English equi verbs exemplify anaphoric control, in contrast with English raising verbs, which exhibit functional control. Equi and raising verbs differ in other ways as well: unlike raising verbs, the controller in an equi construction is semantically as well as syntactically selected by the verb. Notationally, this is reflected in the fact that the SUBJ of an equi verb such as *try* appears inside rather than outside the angled brackets in the semantic form (see Chapter 2, Section 4.6.1):

(63)
$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{try}\langle\textsc{subj},\textsc{comp}\rangle\text{’} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{‘David’} \end{bmatrix} \\ \textsc{comp} & \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{leave}\langle\textsc{subj}\rangle\text{’} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{pro}\text{’} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Since the controller is semantically selected, equi verbs cannot appear with a subordinate COMP verb that selects an expletive or semantically empty subject, since expletive subjects contribute no semantic content and therefore cannot enter into an anaphoric dependency with a controller in the higher clause:

(64) **There tried to be a problem.*

4.1. Semantics of Equi Verbs

Since equi verbs semantically as well as syntactically select for their controller argument, we treat an equi verb like *try* as denoting a two-place predicate, following Halvorsen (1983), Reyle (1988), and many others. The meaning for the sentence *David tried to leave* is therefore:

(65) *David tried to leave.*

$$\mathit{try}(\mathit{David}, \mathit{leave}(\mathit{David}))$$

In (65), *try* denotes a relation between an individual *David* and the proposition $\mathit{leave}(\mathit{David})$ that David is trying to bring about. The equi verb *tried* requires the pronominal subject of the subordinate verb *leave* to be coreferent with the controller subject of *tried*, *David*.

Asudeh (2000, 2002a) proposes an analysis of English equi verbs within the glue framework that differs from the analysis presented here in its assumptions about the syntax and meaning of the complement of the equi verb. Asudeh analyzes equi verbs as taking XCOMP complements, not COMP; further, following Chierchia (1984b,a, 1985), Asudeh claims that the XCOMP of an equi verb denotes a property rather than a proposition. On this view, the meaning of a sentence like *David tried to leave* is represented as:

(66) *David tried to leave.*

$\mathit{try}(\mathit{David}, \lambda x.\mathit{leave}(x))$ (Chierchia 1984a, 1985; Asudeh 2000, 2002a)

In (66), *try* denotes a relation between an individual and the property that the individual aspires to have. Chierchia (1984a) argues for the property theory of control on the basis of entailments like this one:

(67) *Nando tries anything/whatever Ezio tries.*
Ezio tries to jog at sunrise.
―――――――――――――――
Nando tries to jog at sunrise.

On Chierchia's view, the validity of this argument is reflected in the following logical paraphrases:

(68)
$$\begin{array}{l} \forall x.\mathit{try}(\mathit{Ezio}, x) \rightarrow \mathit{try}(\mathit{Nando}, x) \\ \mathit{try}(\mathit{Ezio}, \lambda x.\mathit{jog.at.sunrise}(x)) \\ \hline \mathit{try}(\mathit{Nando}, \lambda x.\mathit{jog.at.sunrise}(x)) \end{array}$$

Chierchia argues that if the complement of the verb *try* is treated as a proposition roughly corresponding to the meaning of a sentence like *Ezio jogs at sunrise*, an unwanted entailment seems to follow, namely that Nando tries for Ezio to jog at sunrise:

(69)
$$\begin{array}{l} \forall x.\mathit{try}(\mathit{Ezio}, x) \rightarrow \mathit{try}(\mathit{Nando}, x) \\ \mathit{try}(\mathit{Ezio}, \mathit{jog.at.sunrise}(\mathit{Ezio})) \\ \hline \mathit{try}(\mathit{Nando}, \mathit{jog.at.sunrise}(\mathit{Ezio})) \end{array}$$

However, there are several difficulties with the property theory of control advocated by Chierchia and Asudeh.[7]

First, Chierchia's proposal is based on the lack of availability of a strict reading for the conclusion of the argument in (67): the conclusion means that Nando tries for Nando (the sloppy reading) and not Ezio (the strict reading) to jog at sunrise.[8] However, other cases of sloppy-only readings for arguments similar to (67) are not amenable to a solution that, like Chierchia's, relies on the property theory of control. For example, the argument in (70) is also valid:

(70) *Nando does anything/whatever Ezio does.*
Ezio$_i$ broke his$_i$ arm playing football.
———————————————
Nando$_j$ broke his$_j$ arm playing football.

However, there is no obvious way in which the canonical representation of the meaning of the sentence *Ezio broke his arm playing football* can be adjusted to predict the validity of the entailment in (70). Thus, whatever means accounts for the sloppy-reading entailment in (70) can presumably account for the validity of the argument in (67) without assuming the property analysis of control.

Additionally, Higginbotham (1992) points out that in at least some cases, arguments analogous to the one in (67) do not provide evidence either for or against Chierchia's position. Higginbotham argues that the entailment in (71) should not be taken as a linguistic fact about the verb *practice*:

(71) *Nando does anything/whatever Ezio does.*
Ezio practices playing the piano.
———————————————
Nando practices playing the piano.

Coreference between the subject of the verb *practice* and the understood subject of the gerund *playing* is enforced by real-world constraints on situations of practicing the piano. Regardless of whether the gerund complement of *practice* is taken to be a property or a proposition, it makes no sense to talk about Nando practicing Ezio's playing the piano. Therefore, Higginbotham argues, examples like this do not shed light on the issue of the type of the complement of equi verbs.

Higginbotham (1992) also discusses examples such as:

(72) *They expected to sit next to each other.*

As Higginbotham points out, this sentence has two readings, paraphrasable in the following way:

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[7]Other authors to have defended the property theory of control include Dowty (1985), Chierchia and Jacobson (1985), and Jacobson (1990).

[8]The distinction between *strict* and *sloppy* readings is best known from analyses of ellipsis (see Dalrymple et al. 1991 and references cited there); in the following, (b) paraphrases the sloppy reading of (a), and (c) paraphrases the strict reading:

(a) *David rode his bike, and Chris did too.*

(b) *Chris rode Chris's bike.* (sloppy)

(c) *Chris rode David's bike.* (strict)

(73) a. *Each of them expects to sit next to the other one.*

b. *They expect: they will sit next to each other.*

On the proposition theory of control adopted here, both of these readings are readily available (we use the notation of Dalrymple et al. 1998 to represent reciprocal meaning).

(74) a. *Each of them expects to sit next to the other one:*

$\mathit{RECIP}(\mathit{they}, \lambda x.\lambda y.\mathit{expect}(x, \mathit{sit.next.to}(x, y)))$

b. *They expect that they will sit next to each other:*

$\mathit{expect}(\mathit{they}, \mathit{RECIP}(\mathit{they}, \lambda x.\lambda y.\mathit{sit.next.to}(x, y)))$

The reading paraphrased in (73a) is also readily available on the property theory.

(75) *Each of them expects to sit next to the other one:*

$\mathit{RECIP}(\mathit{they}, \lambda x.\lambda y.\mathit{expect}(x, \lambda z.\mathit{sit.next.to}(z, y)))$

However, the reading paraphrased in (73b) is difficult to account for on the property theory. It might be thought that the representation in (76) corresponds to the desired interpretation.

(76) *They expect that they will sit next to each other:*

$\mathit{expect}(\mathit{they}, \lambda x.\mathit{RECIP}(x, \lambda z.\lambda y.\mathit{sit.next.to}(z, y)))$

The problem with this representation is that a predicate like *expect* denotes a relation between an individual and the property that the individual expects to have. However, an individual cannot enter into a relationship involving a *RECIP* predicate, which must hold of a group and not an individual. These conflicting requirements make a coherent account of this reading difficult or impossible to obtain under the assumptions of the property theory.

In addition to these arguments, Higginbotham (1992) presents a number of other arguments supporting the proposition theory of control; we conclude with Higginbotham that the proposition theory has clear advantages over the property theory of control, and we adopt the proposition theory here.[9]

4.2. Equi and Obligatory Anaphoric Control

Since we treat the subject of the COMP argument of an equi verb like *tried* as an unexpressed pronoun whose antecedent is the controller, we reintroduce the PCDRT-based meaning constructors used in our analysis of anaphoric binding and the syntax-semantics interface, as discussed in Chapter 14. We assume the following f-structure and meaning for the sentence *David tried to leave*:

[9] For further arguments in favor of the proposition theory of control, see Sag and Pollard (1991) and Pollard and Sag (1994).

(77) *David tried to leave.*

$$t\left[\begin{array}{ll}
\text{PRED} & \text{‘TRY}\langle\text{SUBJ,COMP}\rangle\text{’} \\
\text{SUBJ} & d\left[\begin{array}{ll}\text{PRED} & \text{‘DAVID’}\end{array}\right] \\
\text{COMP} & l\left[\begin{array}{ll}\text{PRED} & \text{‘LEAVE}\langle\text{SUBJ}\rangle\text{’} \\ \text{SUBJ} & p\left[\begin{array}{ll}\text{PRED} & \text{‘PRO’}\end{array}\right]\end{array}\right]
\end{array}\right]$$

$$\begin{array}{|c|}\hline x_1 \\ \hline \mathit{David}(x_1) \\ \mathit{try}(x_1, \begin{array}{|c|}\hline \overline{x_2} \\ \hline \mathit{leave}(\overline{x_2}) \\ \hline \end{array}) \\ \\ \hline \end{array}\ ,\ \mathcal{A}(x_2) = x_1$$

As in Chapter 14, we assume that both the matrix subject *David* and the unexpressed pronominal subject of the complement verb *leave* contribute a discourse referent. The unexpressed pronoun contributes an anaphoric discourse referent, whose antecedent is constrained to be the subject of *try*. The contribution of a discourse referent for the subject of the complement clause allows the resolution of bound anaphors in examples like (78), where the antecedent of the reflexive pronoun *himself* is the unexpressed pronominal subject of *vote*:

(78) *David tried to vote for himself.*

We propose this lexical entry for the equi verb *tried*.

(79) *tried* V

$$\begin{array}{l}
(\uparrow \text{PRED}) = \text{‘TRY}\langle\text{SUBJ,COMP}\rangle\text{’} \\
(\uparrow \text{COMP SUBJ PRED}) = \text{‘PRO’} \\
\mathcal{R}((\uparrow \text{COMP SUBJ})_\sigma\ \text{INDEX}) = ((\uparrow \text{SUBJ})_\sigma\ \text{INDEX}) \\
\lambda x.\lambda P.\begin{array}{|c|}\hline \\ \hline \mathit{try}(x, P) \\ \hline \end{array} \oplus P : (\uparrow \text{SUBJ})_\sigma \multimap [(\uparrow \text{COMP})_\sigma \multimap \uparrow_\sigma] \\
\lambda P.\begin{array}{|c|}\hline \overline{x_1} \\ \hline \\ \hline \end{array} \oplus P(\overline{x_1}) : \forall H.((\uparrow \text{COMP SUBJ})_\sigma \multimap H) \multimap H
\end{array}$$

The first and second lines of this lexical entry are familiar from our syntactic discussion in Section 3.3. The third line establishes the antecedency of the pronominal subject of the COMP argument: semantically, the antecedent of the COMP SUBJ is the matrix clause controller, the SUBJ of *tried*. As discussed in Chapter 14, Section 4.1, this is modeled in terms of the antecedency relation $\mathcal{R}$ between the values of INDEX in the semantic structures projected from the respective f-structures. In (80), we instantiate this constraint according to the f-structure labels in (77):

(80) $\mathcal{R}(p_\sigma\ \text{INDEX}) = (d_\sigma\ \text{INDEX})$

The meaning constructor in the fourth line of the lexical entry, which is labeled **[try]** in (81), provides the main predicate *try*. This PCDRT-based meaning constructor is parallel to that for *arrive*, discussed in Chapter 14, Section 4.3.4, except that in addition to the requirement for the meaning of the SUBJ, it also requires a meaning for the COMP argument, which corresponds to the proposition P on the meaning side.

The final line of the lexical entry is the pronominal meaning constructor supplied by the equi verb for the interpretation of the pronominal SUBJ of its complement clause, labeled **[pro]** in (81). This meaning constructor is similar to the meaning constructor for *he* discussed in Chapter 14, Section 4.3.6, except that, since it is associated with a null pronoun, it imposes no person, number, or gender requirements on the antecedent: in particular, it lacks the requirement for the antecedent to be male.

The instantiated meaning constructors in (81) are relevant in the analysis of (77).

(81) Meaning constructor premises for *David tried to leave*:

[try] $\lambda x.\lambda P.\begin{array}{|c|}\hline \\ \hline \textit{try}(x, P) \\ \hline \end{array} \oplus P \;:\; d_\sigma \multimap [l_\sigma \multimap t_\sigma]$

[David] $\lambda P.\begin{array}{|c|}\hline x_1 \\ \hline \textit{David}(x_1) \\ \hline \end{array} \oplus P(x_1) \;:\; \forall H.(d_\sigma \multimap H) \multimap H$

[leave] $\lambda x.\begin{array}{|c|}\hline \\ \hline \textit{leave}(x) \\ \hline \end{array} \;:\; p_\sigma \multimap l_\sigma$

[pro] $\lambda P.\begin{array}{|c|}\hline \overline{x_1} \\ \hline \\ \hline \end{array} \oplus P(\overline{x_1}) \;:\; \forall H.(p_\sigma \multimap H) \multimap H$

We first combine **[pro]** with **[leave]**, producing the meaning constructor **[pro-leave]**.

(82) **[pro-leave]** $\begin{array}{|c|}\hline \overline{x_1} \\ \hline \textit{leave}(\overline{x_1}) \\ \hline \end{array} : l_\sigma$

We also combine **[David]** with the meaning constructor **[try]** to produce the meaning constructor **[David-try]**.[10]

(83) **[David-try]** $\lambda P.\begin{array}{|c|}\hline x_1 \\ \hline \textit{David}(x_1) \\ \textit{try}(x_1, P) \\ \hline \end{array} \oplus P : l_\sigma \multimap t_\sigma$

[10]As defined in Chapter 8, Section 8.1.1, the variable H ranges over semantic structures. In order to apply the meaning **[David]** to the meaning **[try]**, it is therefore necessary first to hypothesize (Chapter 8, Section 8.1.4) meanings for the SUBJ and COMP of try, and then to discharge the hypothesized subject meaning, resulting in a meaning: **[try-P]** $\lambda x.\begin{array}{|c|}\hline \\ \hline \textit{try}(x, P) \\ \hline \end{array} \oplus P : d_\sigma \multimap t_\sigma$. The meaning **[David]** is then applied to the meaning **[try-P]**, following which the hypothesized meaning P is discharged, resulting in the meaning **[David-try]**. Here, and elsewhere in this chapter, we pass over the details of such abstractions, describing meanings like **[David]** as directly applying to meanings like **[try]**.

The meaning constructor **[David-try]** in (83) requires a meaning resource for l_σ, which is provided by **[pro-leave]**. Combining **[David-try]** and **[pro-leave]**, we have the meaning constructor labeled **[David-try-pro-leave]**.[11]

(84) **[David-try-pro-leave]**
$$\begin{array}{|c|}\hline x_1 \\ \hline \mathit{David}(x_1) \\ \mathit{try}(x_1, \begin{array}{|c|}\hline \overline{x_2} \\ \hline \mathit{leave}(\overline{x_2}) \\ \hline \end{array}) \\ \\ \hline \end{array} : t_\sigma$$

We have now produced a complete meaning for (77), but the anaphoric discourse referent $\overline{x_2}$ still requires an antecedent. According to the constraint in the fifth line of (79), the function $\mathcal{R}$ applied to the s-structure INDEX feature corresponding to the pronoun finds the INDEX feature corresponding to *David*. Thus, we can augment the meaning constructor in (84) with the correct antecedency relation.

(85) **[David-try-pro-leave]**
$$\begin{array}{|c|}\hline x_1 \\ \hline \mathit{David}(x_1) \\ \mathit{try}(x_1, \begin{array}{|c|}\hline \overline{x_2} \\ \hline \mathit{leave}(\overline{x_2}) \\ \hline \end{array}) \\ \\ \hline \end{array} : t_\sigma,\ \mathcal{R}(2) = 1$$

4.3. Equi and Functional Control

In Section 3.2, we saw that some equi verbs in Tagalog involve functional rather than anaphoric control. Example (54), repeated here, exemplifies functional control:

(86) *nagpilit* *si-Maria-ng* *bigy-an* *ng-pera* *ni-Ben*
PRF.AV.insist.on NOM-Maria-COMP give-DAT GEN-money GEN-Ben
'Maria insisted on being given money by Ben.'

$$i\left[\begin{array}{ll} \text{PRED} & \text{`INSIST}\langle\text{SUBJ,XCOMP}\rangle\text{'} \\ \text{SUBJ} & m\left[\begin{array}{ll}\text{PRED} & \text{`MARIA'}\end{array}\right] \\ \text{XCOMP} & g\left[\begin{array}{ll} \text{PRED} & \text{`GIVE}\langle\text{SUBJ,OBJ,OBJ}_{\text{AGENT}}\rangle\text{'} \\ \text{SUBJ} & \\ \text{OBJ} & f\left[\begin{array}{ll}\text{PRED} & \text{`MONEY'}\end{array}\right] \\ \text{OBJ}_{\text{AGENT}} & b\left[\begin{array}{ll}\text{PRED} & \text{`BEN'}\end{array}\right] \end{array}\right] \end{array}\right]$$

$\mathit{insist}(\mathit{Maria}, \mathit{give}(\mathit{Ben}, \mathit{money}, \mathit{Maria})) : i_\sigma$

[11]Notice that the discourse referents in (82) have been renumbered to avoid a clash with those in (83); see Chapter 14, Section 4.3.6 for discussion.

Since this example involves functional rather than anaphoric control, anaphora resolution is not a central issue in the derivation of its meaning, and we use simple meaning constructors rather than PCDRT constructors.

We assume that the XCOMP complement of the equi verb *nagpilit* 'insist on' patterns with other equi verbs in denoting a proposition, though we have not been able to verify the semantic patterns presented in Section 4.1 with a native speaker of Tagalog. On this assumption, we propose the following lexical entry for *nagpilit* 'insist on'.

(87) *nagpilit* V $(\uparrow \text{PRED}) = \text{`INSIST}\langle\text{SUBJ,XCOMP}\rangle\text{'}$
$(\uparrow \text{SUBJ}) = (\uparrow \text{XCOMP SUBJ})$
$\lambda P.\lambda x.\mathit{insist}(x, P(x))$:
$[(\uparrow \text{SUBJ})_\sigma \multimap (\uparrow \text{XCOMP})_\sigma] \multimap [(\uparrow \text{SUBJ})_\sigma \multimap \uparrow_\sigma]$

The first and second lines of this lexical entry enforce the syntactic constraints appropriate for a subject raising verb. The last line gives the meaning constructor for this verb, which requires two arguments: an implicational resource $[(\uparrow \text{SUBJ})_\sigma \multimap (\uparrow \text{XCOMP})_\sigma]$ corresponding to its XCOMP argument and a resource $(\uparrow \text{SUBJ})_\sigma$ corresponding to its subject. The XCOMP resource takes the form of an implication because it is an argument that is "missing" its subject (which is also the subject of the main verb). The subject's meaning is represented by x on the left-hand side of the meaning constructor in (87); the XCOMP's meaning is the property P, which is applied to the subject meaning x to produce the proposition $P(x)$ filling the second argument position of *insist*.

The meaning constructor in the lexical entry in (87) is labeled **[insist]** in (88), instantiated with the f-structure labels given in (86); we also provide the standard meaning constructors for the proper names *Maria* and *Ben* and for the ditransitive verb *bigy-an* 'give'. Since the internal structure of the noun phrase *ng-pera* 'money' is not at issue here, we make the simplifying assumption that this noun phrase makes a contribution like that of a proper name and has the meaning *money*.

(88) Meaning constructor premises for *nagpilit si-Maria-ng bigy-an ng-pera ni-Ben*:

[insist]	$\lambda P.\lambda x.\mathit{insist}(x, P(x))$	:	$[m_\sigma \multimap g_\sigma] \multimap [m_\sigma \multimap i_\sigma]$
[Maria]	Maria	:	m_σ
[give]	$\lambda x.\lambda y.\lambda z.\mathit{give}(x, y, z)$	:	$b_\sigma \multimap [f_\sigma \multimap [m_\sigma \multimap g_\sigma]]$
[money]	money	:	f_σ
[Ben]	Ben	:	b_σ

We first combine the premises labeled **[Ben]**, **[money]**, and **[give]** to produce the meaning constructor labeled **[give-Ben-money]**.

(89) **[give-Ben-money]** $\lambda z.\mathit{give}(\mathit{Ben}, \mathit{money}, z) : m_\sigma \multimap g_\sigma$

This meaning constructor provides the implicational resource $m_\sigma \multimap g_\sigma$ required by the meaning constructor labeled **[insist]**. On the left-hand side, we obtain the corresponding meaning by applying the function $\lambda P.\lambda x.\mathit{insist}(x, P(x))$ to its argument $\lambda z.\mathit{give}(\mathit{Ben}, \mathit{money}, z)$. Combining **[give-Ben-money]** and **[insist]**, we have the meaning constructor labeled **[insist-give-Ben-money]** in (90).

(90) **[insist-give-Ben-money]** $\lambda x.\mathit{insist}(x, \mathit{give}(\mathit{Ben}, \mathit{money}, x)) : m_\sigma \multimap i_\sigma$

Finally, we combine this meaning constructor with the subject meaning constructor, labeled **[Maria]**. The resulting meaning constructor, displayed in (91), provides a semantically complete and coherent meaning for this example.

(91) **[insist-give-Ben-money]**, **[Maria]** $\vdash$

$$\mathit{insist}(\mathit{Maria}, \mathit{give}(\mathit{Ben}, \mathit{money}, \mathit{Maria})) : i_\sigma$$

5. ARBITRARY ANAPHORIC CONTROL

5.1. Syntax of Arbitrary Control

As we have argued above, English equi verbs such as *try* or *persuade* participate in obligatory anaphoric control, where the referent of the controlled subordinate clause SUBJ is determined by constraints associated with the matrix verb. This situation contrasts with constructions involving *arbitrary control*, in which the reference of the pronominal element in the subordinate clause is not syntactically determined. In an arbitrary control construction, the reference of the controlled argument in the subordinate clause is resolved much like an overt nonreflexive pronoun, as described by Bresnan (1982a) and Bresnan et al. (2016). Example (92) involves arbitrary anaphoric control and means that David gestured for some unspecified individual or individuals to follow Chris:

(92) *David gestured to follow Chris.*

$$\left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{gesture}\langle\textsc{subj},\textsc{comp}\rangle\text{’} \\
\textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{‘David’}\end{array}\right] \\
\textsc{comp} & \left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{follow}\langle\textsc{subj},\textsc{obj}\rangle\text{’} \\
\textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{pro}\text{’}\end{array}\right] \\
\textsc{obj} & \left[\begin{array}{ll}\textsc{pred} & \text{‘Chris’}\end{array}\right]
\end{array}\right]
\end{array}\right]$$

There are a number of differences between arbitrary control and functional or obligatory anaphoric control. Bresnan (1982a) and Bresnan et al. (2016) show that for arbitrary anaphoric control, though not for functional or obligatory anaphoric control, a split antecedent (an antecedent that does not form a syntactic unit) is possible. In (93), the subject of *follow* can be interpreted as the group consisting of Chris and Matty, even though there is no single constituent representing this group in the matrix clause:

(93) *Chris told Matty that David had gestured to follow Ken.*
[possible interpretation: Chris and Matty follow Ken]

A syntactically remote antecedent is also possible. In (94), the subject of *follow* can be interpreted as coreferent with *Chris*, although the noun phrase *Chris* is not an argument of the immediately higher clause:

(94) *Chris thought that it was clear that David had gestured to follow Ken.*
[possible interpretation: Chris follows Ken]

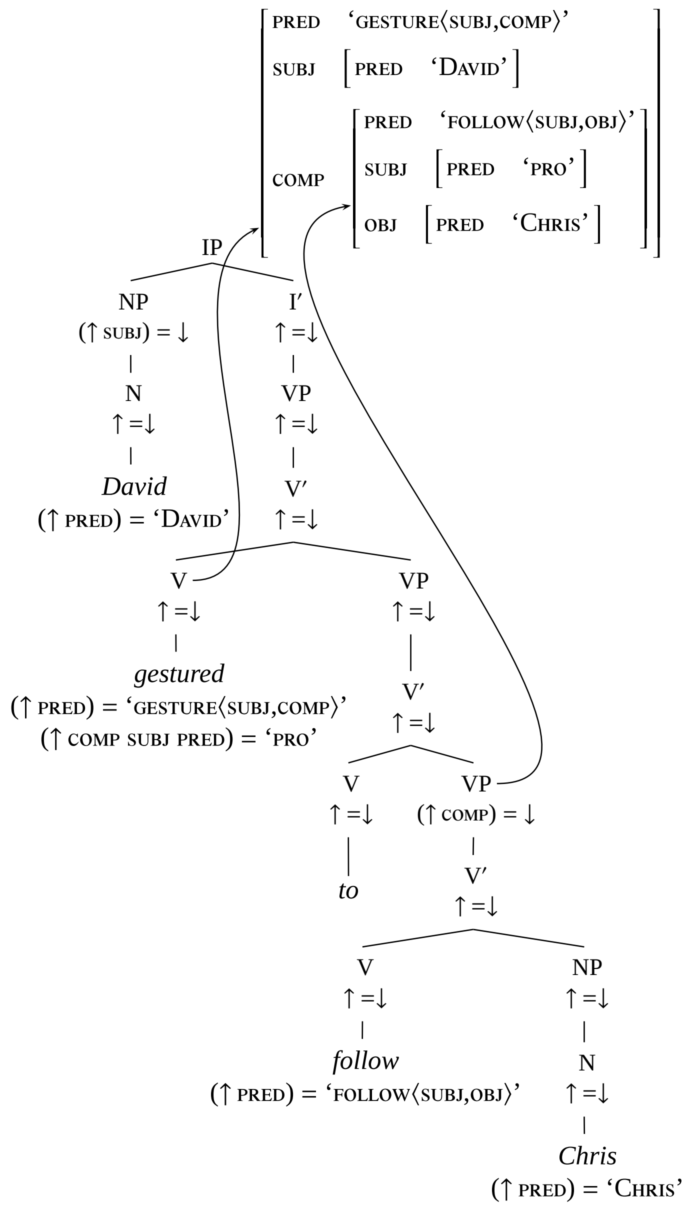
Additionally, there may be no expressed antecedent in the same sentence at all, as in (92).

These semantic differences will emerge more clearly in the next section when we discuss the interpretation of arbitrary anaphoric control constructions. Syntactically, obligatory and arbitrary control constructions do not differ; the same phrase structure rule, given in (56), covers both, and the syntactic portions of the lexical entries are similar. We propose the following syntactic lexical entry for a verb like *gesture*:

(95) *gesture* V $(\uparrow \textsc{pred}) = \text{‘}\textsc{gesture}\langle\textsc{subj},\textsc{comp}\rangle\text{’}$
$(\uparrow \textsc{comp subj pred}) = \text{‘}\textsc{pro}\text{’}$

Example (96) shows the c-structure and f-structure for the example *David gestured to follow Chris*.

(96) *David gestured to follow Chris.*



5.2. Semantics of Arbitrary Control

Consider this short discourse:

(97) *Chris yawned. David gestured to leave.*

The most likely interpretation of the sentence *David gestured to leave* in (97) is that David gestured for Chris to leave:

(98) *Chris yawned. David gestured to leave.*

$$\mathit{yawn}(\mathit{Chris}), \mathit{gesture}(\mathit{David}, \mathit{leave}(\mathit{Chris}))$$

In other contexts, other antecedents are possible. Unlike the situation with obligatory anaphoric control, lexical or syntactic constraints do not determine the referent of the complement subject. Instead, the pronominal subject of the complement *to leave* obeys the same constraints on pronoun resolution as an overt pronoun.

However, lexical constraints can play an important role in constraining the range of possible referents for the controller in an arbitrary control construction. In (98), the matrix subject in the second sentence cannot corefer with the subject of the COMP: that is, a sentence like *David gestured to leave* cannot mean that David gestured for himself to leave. This is a *negative constraint* on anaphoric reference, which in this case is imposed by the verb *gesture*; negative constraints were discussed in Sections 2.2 and 4.3 of Chapter 14.

5.3. Arbitrary Control and Meaning Assembly

Since the unexpressed subject of the COMP of the verb *gestured* is interpreted as a pronominal whose antecedent must be resolved, we require a representation of the context in the derivation of the meanings of the sentences in the discourse in (97). The f-structure and meaning constructor for the first sentence are:

(99) *Chris yawned.*

$$y\left[\begin{array}{ll} \text{PRED} & \text{‘YAWN}\langle\text{SUBJ}\rangle\text{’} \\ \text{SUBJ} & c\left[\begin{array}{ll} \text{PRED} & \text{‘CHRIS’} \end{array}\right] \end{array}\right]$$

$$\begin{array}{|c|}\hline x_1 \\ \hline \mathit{Chris}(x_1) \\ \mathit{yawn}(x_1) \\ \hline \end{array} : y_\sigma$$

We assume the premises in (100) for the analysis of this sentence.

(100) Meaning constructor premises for *Chris yawned*:

$$
\begin{array}{lrl}
\textbf{[context]} & \begin{array}{|c|}\hline \\ \hline \\ \hline \end{array} & : (y_\sigma\ \textsc{context}) \\[1ex]
\textbf{[context-mod]} & \lambda P.\lambda Q.P \oplus Q & : y_\sigma \multimap (y_\sigma\ \textsc{context}) \multimap (y_\sigma\ \textsc{context}) \\[1ex]
\textbf{[yawn]} & \lambda x. \begin{array}{|c|}\hline \\ \hline \mathit{yawn}(x) \\ \hline \end{array} & : c_\sigma \multimap y_\sigma \\[1ex]
\textbf{[Chris]} & \lambda P. \begin{array}{|c|}\hline x_1 \\ \hline \mathit{Chris}(x_1) \\ \hline \end{array} \oplus P(x_1) & : \forall H.(c_\sigma \multimap H) \multimap H
\end{array}
$$

The first two premises in (100) are identical to those presented in (87) and (88) of Chapter 14 in the analysis of the sentence *David arrived* in context at the start of a discourse. The derivation of the meaning of this sentence proceeds analogously. Combining these premises produces the following semantically complete and coherent meaning constructor, as desired.

(101) $$\textbf{[context]}, \textbf{[context-mod]}, \textbf{[yawn]}, \textbf{[Chris]} \vdash \begin{array}{|c|}\hline x_1 \\ \hline \mathit{Chris}(x_1) \\ \mathit{yawn}(x_1) \\ \hline \end{array} : (y_\sigma\ \textsc{context})$$

The second sentence in (97), *David gestured to leave*, has the following f-structure and meaning constructor.

(102) *David gestured to leave.*

$$
g\left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{gesture}\langle\textsc{subj},\textsc{comp}\rangle\text{’} \\[1ex]
\textsc{subj} & d\left[\begin{array}{ll}\textsc{pred} & \text{‘David’}\end{array}\right] \\[1ex]
\textsc{comp} & l\left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{leave}\langle\textsc{subj}\rangle\text{’} \\
\textsc{subj} & p\left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{pro}\text{’}\end{array}\right]
\end{array}\right]
\end{array}\right]
$$

$$
\begin{array}{|c|}\hline x_1 \\ \hline \mathit{David}(x_1) \\ \mathit{gesture}(x_1, \begin{array}{|c|}\hline \overline{x_2} \\ \hline \mathit{leave}(\overline{x_2}) \\ \hline \end{array}) \\ \\ \hline \end{array} : g_\sigma
$$

The lexical entry for the arbitrary control verb *gestured* is as follows.

(103) *gestured* V $(\uparrow \text{PRED}) = \text{`GESTURE}\langle\text{SUBJ,COMP}\rangle\text{'}$
$(\uparrow \text{COMP SUBJ PRED}) = \text{`PRO'}$

$\mathcal{R}^*((\uparrow \text{COMP SUBJ})_\sigma \text{ INDEX}) \neq \mathcal{R}^*((\uparrow \text{SUBJ})_\sigma \text{ INDEX})$

$\lambda x.\lambda P. \begin{array}{|c|}\hline \\ \hline \textsf{gesture}(x, P) \\ \hline\end{array} \oplus P : (\uparrow \text{SUBJ})_\sigma \multimap [(\uparrow \text{COMP})_\sigma \multimap \uparrow_\sigma]$

$\lambda P. \begin{array}{|c|}\hline \overline{x_1} \\ \hline \\ \hline\end{array} \oplus P(\overline{x_1}) : \forall H.((\uparrow \text{COMP SUBJ})_\sigma \multimap H) \multimap H$

The first line of this lexical entry provides the PRED value for the verb *gestured*. The second line of the lexical entry specifies a 'PRO' value for the PRED attribute of the complement clause's subject. The third line introduces a constraint on its antecedent:

(104) $\mathcal{R}^*((\uparrow \text{COMP SUBJ})_\sigma \text{ INDEX}) \neq \mathcal{R}^*((\uparrow \text{SUBJ})_\sigma \text{ INDEX})$

As noted earlier, the SUBJ of *gesture* cannot corefer with its COMP SUBJ: the sentence *David gestured to leave* cannot mean that David gestured for himself to leave. The constraint in (104) enforces this requirement by preventing the complement's subject's semantic structure INDEX $((\uparrow \text{COMP SUBJ})_\sigma \text{ INDEX})$ from being related to the INDEX of $(\uparrow \text{SUBJ})_\sigma$ via the $\mathcal{R}^*$ relation.[12]

The fourth line in (103) is the meaning constructor that introduces the predicate *gesture*, labeled **[gesture]** in (105); it is analogous to the meaning for *try* given in (79).

The final line of the lexical entry in (103) provides a pronominal meaning constructor for the COMP SUBJ of *gesture*, labeled **[pro]** in (105). Again, this meaning constructor is identical to that found in the lexical entry of the equi verb *try* in (79), and is similar to the meaning constructor for *he* discussed in Chapter 14, Section 4.3.6, except that it lacks the requirement that the antecedent be male.

With the context **[context]** produced by uttering the first sentence in the discourse, *Chris yawned*, the premises in (105) are relevant for the deduction of the meaning of *David gestured to leave*.

[12]For discussion of negative binding constraints and the $\mathcal{R}^*$ relation, see Chapter 14, Section 4.3.2.

(105) Meaning constructor premises for *David gestured to leave*:

[context] $\begin{array}{|c|}\hline x_1 \\ \hline \textit{Chris}(x_1) \\ \textit{yawn}(x_1) \\ \hline\end{array} \;:\; (g_\sigma\ \textsc{context})$

[context-mod] $\lambda P.\lambda Q.P \oplus Q \;:\; g_\sigma \multimap (g_\sigma\ \textsc{context}) \multimap (g_\sigma\ \textsc{context})$

[gesture] $\lambda x.\lambda P.\begin{array}{|c|}\hline \\ \hline \textit{gesture}(x, P) \\ \hline\end{array} \oplus P \;:\; d_\sigma \multimap [l_\sigma \multimap g_\sigma]$

[David] $\lambda P.\begin{array}{|c|}\hline x_1 \\ \hline \textit{David}(x_1) \\ \hline\end{array} \oplus P(x_1) \;:\; \forall H.(d_\sigma \multimap H) \multimap H$

[pro] $\lambda P.\begin{array}{|c|}\hline \overline{x_1} \\ \hline \\ \hline\end{array} \oplus P(\overline{x_1}) \;:\; \forall H.(p_\sigma \multimap H) \multimap H$

[leave] $\lambda x.\begin{array}{|c|}\hline \\ \hline \textit{leave}(x) \\ \hline\end{array} \;:\; p_\sigma \multimap l_\sigma$

We first combine **[David]** with **[gesture]** to produce this meaning constructor.

(106) **[David-gesture]** $\lambda P.\begin{array}{|c|}\hline x_1 \\ \hline \textit{David}(x_1) \\ \textit{gesture}(x_1, P) \\ \hline\end{array} \oplus P : l_\sigma \multimap g_\sigma$

We also combine the meaning constructor **[pro]** with **[leave]** to produce **[pro-leave]**.

(107) **[pro-leave]** $\begin{array}{|c|}\hline \overline{x_1} \\ \hline \textit{leave}(\overline{x_1}) \\ \hline\end{array} : l_\sigma$

We can now combine **[David-gesture]** with **[pro-leave]**, producing the meaning constructor labeled **[David-gesture-pro-leave]**.[13]

(108) **[David-gesture-pro-leave]** $\begin{array}{|c|}\hline x_1 \\ \hline \textit{David}(x_1) \\ \textit{gesture}(x_1, \begin{array}{|c|}\hline \overline{x_2} \\ \hline \textit{leave}(\overline{x_2}) \\ \hline\end{array}) \\ \\ \hline\end{array} : g_\sigma$

Since *David gestured to leave* is a root sentence like *Chris yawned*, we must also make use of the meaning constructor labeled **[context-mod]** in (105), reflecting its role as a context modifier. Combining **[context-mod]** with the meaning constructor in (108) produces the context-modifying meaning constructor in (109).

(109) **[David-gesture-pro-leave-mod]** $\begin{array}{|c|}\hline x_1 \\ \hline \textit{David}(x_1) \\ \textit{gesture}(x_1, \begin{array}{|c|}\hline \overline{x_2} \\ \hline \textit{leave}(\overline{x_2}) \\ \hline\end{array}) \\ \\ \hline\end{array} : (g_\sigma\ \textsc{context}) \multimap (g_\sigma\ \textsc{context})$

[13] As in (84), the discourse referents in (107) have been renumbered to prevent a clash with the discourse referents in (106).

The discourse context for this sentence is the meaning constructor labeled **[context]** in (105), which was derived in (101). The meaning constructor in (109) functions as a modifier on this context, producing an updated context which includes the contribution of the sentence *David gestured to leave*. Combining the meaning **[David-gesture-pro-leave-mod]** with **[context]**, and rewriting indices as needed, we arrive at the following meaning for the discourse:

(110)
$$\begin{array}{|c|}\hline x_1, x_2 \\ \hline \textit{Chris}(x_1) \\ \textit{yawn}(x_1) \\ \textit{David}(x_2) \\ \textit{gesture}(x_2, \begin{array}{|c|}\hline \overline{x_3} \\ \hline \textit{leave}(\overline{x_3}) \\ \hline \end{array}) \\ \\ \hline \end{array} : (g_\sigma\ \text{CONTEXT})$$

Finally, we find a licit antecedent for the anaphoric discourse referent x_3. By the negative constraint in the lexical entry for *gesture*, the discourse referent x_2 is not a licit antecedent for x_3. The discourse referent x_1 is available to serve as the antecedent of x_3, so the pragmatic resolution function $\mathcal{R}$ may apply to the index corresponding to x_3 to establish an anaphoric relation to the index of x_1:

(111)
$$\begin{array}{|c|}\hline x_1, x_2 \\ \hline \textit{Chris}(x_1) \\ \textit{yawn}(x_1) \\ \textit{David}(x_2) \\ \textit{gesture}(x_2, \begin{array}{|c|}\hline \overline{x_3} \\ \hline \textit{leave}(\overline{x_3}) \\ \hline \end{array}) \\ \\ \hline \end{array} : (g_\sigma\ \text{CONTEXT}),\ \ \mathcal{R}(3) = 1$$

6. PARTIAL ('QUASI-OBLIGATORY') CONTROL

In the preceding sections we have drawn a contrast between obligatory anaphoric control, as exemplified by English equi verbs such as *try*, and arbitrary anaphoric control, as exemplified by the verb *gesture*. However, this binary distinction does not account for the full variety of anaphoric control possibilities, even in English. As argued in detail by Haug (2013), the phenomenon of 'partial control' is best analyzed as a kind of 'quasi-obligatory' anaphoric control, in which the constraints on the resolution of the controlled pronoun are looser than the constraints involved in obligatory anaphoric control, but stronger than those involved in arbitrary anaphoric control. Partial control is exemplified in the following sentences (Haug 2013):

(112) a. *The chair$_i$ preferred to gather$_{i+}$ at six.*

b. *John$_i$ told Mary$_j$ that he$_i$ preferred to meet$_{i+}$ at six today.*

c. *Mary wants to bomb Hanoi.*

In (112a), there is an inclusion relation between the controlled argument and its controller in the matrix clause: the subject of *gather* is a group, for example a committee, which includes the chair of that committee. The same is true in (112b): the subject of *meet* must be a group of at least two individuals, which may or may not include Mary, but must include John. In (112c) the situation is slightly different: this sentence is felicitous in a situation where Mary herself does not want to be directly involved in the bombing, but wants some salient and related referent to bomb Hanoi, for example her country's airforce.

Partial control has been investigated by a number of authors, including Landau (2000, 2004) and Grano (2015). Within LFG, the first author to address this phenomenon was Asudeh (2005), who proposed an analysis involving functional control. Haug (2013) shows that a functional control analysis is not viable, and provides a semantically-based anaphoric control analysis within the PCDRT framework adopted in this work (Haug 2014b). Haug (2013, 2014a) proposes to account for partial control by enriching the pragmatic resolution function $\mathcal{A}$ in such a way as to license relations other than identity between anaphor and antecedent, for example a relation of inclusion. Specifically, Haug proposes that the validity of the relation $\mathcal{A}$ between anaphor and antecedent depends on an additional relation $\mathcal{B}$: the relation $\mathcal{A}$ is valid if and only if an appropriate $\mathcal{B}$ relation holds between the antecedent and the anaphor. For example, we can represent the meaning and control resolution of example (112a) as follows:

(113)
$$\begin{array}{|c|}\hline x_1 \\ \hline \mathit{chair}(x_1) \\ \mathit{prefer}(x_1, \begin{array}{|c|}\hline \overline{x_2} \\ \hline \mathit{gather.at.six}(\overline{x_2}) \\ \hline \end{array}) \\ \\ \hline \end{array}\ , \ \mathcal{A}(x_2) = x_1; \mathcal{B} = \lambda x.\lambda y.\mathit{chair}(x, y)$$

Here, the antecedent relation holds between x_2 and x_1, because the relation $\lambda x.\lambda y.\mathit{chair}(x, y)$ holds between x_1 and x_2. In all of the examples discussed in the previous sections, the $\mathcal{A}$ relation indicates coreference, and this can be modeled as a default interpretation of $\mathcal{B}$ as $\lambda x.\lambda y.x = y$. The possibilities of anaphoric resolution, which are significantly increased by the extension of $\mathcal{B}$ beyond coreference, are constrained in different ways by the specific semantic properties of different control verbs; for example, a constraint associated with *prefer* ensures that the controlled argument in (112a) includes the logophoric center of the control verb, in this case the subject.

Thus, the model of anaphoric control presented above is capable of capturing a wide variety of constraints on the anaphoric resolution of the controlled argument, from strict syntactic constraints in obligatory anaphoric control, to more flexible semantic constraints in partial control, and relative freedom of resolution in the case of arbitrary control.

7. THE CONTROLLER IN ANAPHORIC OR FUNCTIONAL CONTROL

Determination of the controller in functional and obligatory anaphoric control is constrained by both syntactic and semantic factors. In both kinds of control constructions, the controller must be a *term* (Chapter 2, Section 1.3). Further, as discussed in detail by Sag and Pollard (1991), the choice of controller in equi verbs is semantically constrained; equi verbs can be divided into semantic classes, and the semantic role of the controller can be predicted from these classes.

7.1. Syntactic Requirements

Bresnan (1982a) presents the following constraints on determination of the controller in control constructions:

(114) a. The controller must be a term (SUBJ, OBJ, or OBJ$_{\theta}$).

b. By default, the controller is the lowest available argument on the grammatical function hierarchy SUBJ > OBJ > OBJ$_{\theta}$.

The first requirement is that the controller is required to be a term: either SUBJ, OBJ, or OBJ$_{\theta}$. As demonstrated by Bresnan (1982a), this makes several strikingly correct predictions.

First, it accounts for what is known as *Visser's Generalization* (Visser 1963–1973; Bresnan 1982a), according to which there is no passive version of a verb involving subject control:[14]

(115) a. *<u>John</u> promised Mary to be on time.*

b. **Mary was promised by <u>John</u> to be on time.*

(116) a. *<u>He</u> strikes his friends as pompous.*

b. **His friends are struck by <u>him</u> as pompous.*

Visser's Generalization follows from the constraint in (114a) since an oblique or adjunct phrase such as *by John* is not a term and therefore cannot participate as a controller in a control construction.

[14] As discussed by van Urk (2013), impersonal passives such as the following constitute an exception to this generalization:

(a) It was decided to leave.

(b) *Es wurde versucht, Eichhörnchen zu fangen.*
it was tried squirrels to catch
'It was tried to catch squirrels.'

Such examples constitute an exception to Visser's Generalization, but do not violate the constraint in (114a): there is no explicit controller, so whatever the correct analysis of such sentences, they cannot involve functional or obligatory anaphoric control.

Second, the constraint in (114a) accounts for what is known as *Bach's Generalization* (Bach 1980): there is no detransitivized version of a verb involving object control. Bresnan (1982a) presents the following illustrative examples, which involve both functional and anaphoric control.

(117) Anaphoric control by subject:

a. *Louise promised Tom to be on time.*

b. *Louise promised to be on time.*

(118) Anaphoric control by object:

a. *Louise taught Tom to smoke.*

b. **Louise taught to smoke.*

(119) Functional control by object:

a. *Louise believed Tom to smoke.*

b. **Louise believed to smoke.*

Bach's Generalization follows from the constraint in (114a), since the controller must be present as a term argument in a control construction.[15] Of course, Bach's Generalization does not apply to arbitrary anaphoric control constructions, since there are no syntactic constraints on the determination of the controller of the subject of the subordinate COMP in an arbitrary anaphoric control construction:

(120) a. *Louise signaled Tom to follow.*

b. *Louise signaled to follow.*

The requirement in (114b) involves a violable syntactic hierarchy of default controllers in control constructions: Bresnan (1982a) claims that the unmarked choice for a controller is OBJ_θ if there is one, otherwise OBJ if there is one, and otherwise SUBJ. The following control constructions obey this rule:

(121) a. *David tried to leave.*

b. *David persuaded Chris to leave.*

Verbs like *promise* constitute exceptions to this default, since the SUBJ and not the OBJ is the controller:

[15] Many verbs which show object control entirely lack a detransitivized version, even when they have no controlled complement:

(a) Louise believed *(Tom) regarding his accident.

(b) Louise convinced *(Tom) of her innocence.

Nevertheless, some such verbs do permit detransitivized versions outside control contexts, supporting the validity of Bach's Generalization:

(c) Louise taught (them) about anaphoric binding.

(122) <u>*Chris*</u> *promised David to leave.*

Both of the generalizations in (114) are best thought of as constraining the determination of grammatical functions for verbs involving functional or anaphoric control; for discussion of the theory of mapping between semantic roles and grammatical functions, see Chapter 9.

7.2. Semantic Requirements

In addition to syntactic constraints on how the controller is realized, there are also semantic generalizations about controller choice in constructions involving equi verbs (which, as shown above, can involve either functional or anaphoric control). Sag and Pollard (1991) and Pollard and Sag (1994) provide a detailed exploration of different classes of equi verbs and propose semantic principles for determination of the controller in equi constructions. For example, they propose that verbs such as *order*, *persuade*, and *bid* are members of what they call the *order/permit* class of equi verbs. Verbs of this class refer to situations where a participant is influenced by another participant to perform a certain action, and the controller is always the OBJ argument of the active equi verb. This class contrasts with the *promise* class, containing verbs like *promise*, *agree*, and *demand*, in which the controller is always the SUBJ of the active equi verb. Thus, generalizations about linking in equi verbs — how the semantic arguments of these verbs are linked to the syntactic functions SUBJ, OBJ, OBJ_θ, and COMP, as described in Chapter 9 — are formulated with reference to these larger classes, not separately specified for each verb. Within LFG, the shared properties of such classes are captured by the use of templates (Chapter 6, Section 7). Sag and Pollard's useful classifications are used in analyses of control in Balinese by Arka (1998) and Arka and Simpson (1998). As discussed in Section 6, semantic constraints are also relevant to the analysis of partial control, as shown by Haug (2013, 2014a).

8. CONTROL IN ADJUNCTS

Thus far, we have examined functional and anaphoric control involving the closed grammatical function COMP and the open function XCOMP. Modifiers may also participate in either functional or anaphoric control. The open function XADJ contains an open position which is functionally controlled by an argument of the matrix clause, and some modifying adjuncts with the closed function ADJ participate in anaphoric control. Mohanan (1983) discusses control in modifier phrases, showing that control relations must be defined in functional and not phrasal terms: English and Malayalam are quite different in constituent structure, but obey similar functional constraints in control constructions.

8.1. Functional Control and XADJ

The open adjunct function XADJ is similar to the open function XCOMP in participating in functional control. The SUBJ of the XADJ is identified with an argument of the matrix clause, and the same f-structure fills both functions. Andrews (1990a) discusses the following Icelandic examples involving control of an XADJ:[16]

(123) *Njósnaranum var kastað einum út úr þyrlunni.*
spy.DEF.DAT was thrown alone.DAT out from helicopter.DEF
'The spy was thrown out of the helicopter alone.'

(124) *Ég mætti Sveini drukknum.*
I met Svein.DAT drunk.DAT
'I met Svein drunk.'

In (123) and (124), the dative form of the open XADJ adjuncts *einum* 'alone' and *drukknum* 'drunk' appears. Andrews (1990a) shows that the subjects of these open adjuncts are functionally controlled by a term argument of the matrix verb. In particular, in (124) the object *Sveini* 'Svein' appears in dative case, as the verb *mætti* 'met' requires, and the SUBJ of the dative adjunct *drukknum* 'drunk' is controlled by the matrix dative OBJ *Sveini*.

We propose the rule in (125) for XADJ in Icelandic, which allows for the XADJ phrase *drukknum* 'drunk' to be adjoined to a VP:[17]

(125)
$$\text{VP} \longrightarrow \begin{pmatrix}\text{VP}\\ \uparrow=\downarrow\end{pmatrix} \quad \begin{array}{c}\text{AP}^{*}\\ \downarrow\in(\uparrow\ \textsc{xadj})\\ (\uparrow\{\textsc{subj}|\textsc{obj}|\textsc{obj}_{\theta}\}) = (\downarrow\ \textsc{subj})\end{array}$$

According to this rule, the SUBJ of the open adjunct XADJ is identified with a term argument of the matrix clause: a SUBJ, OBJ, or $\textsc{obj}_{\theta}$. We also propose the lexical entry in (126) for the adjective *drukknum* 'drunk', which requires a dative subject:

(126) *drukknum* A $(\uparrow \textsc{pred}) = \text{`}\textsc{drunk}\langle\textsc{subj}\rangle\text{'}$
$(\uparrow \textsc{subj case}) = \textsc{dat}$

The case constraint imposed by *drukknum* is satisfied by the dative noun phrase *Sveini*:

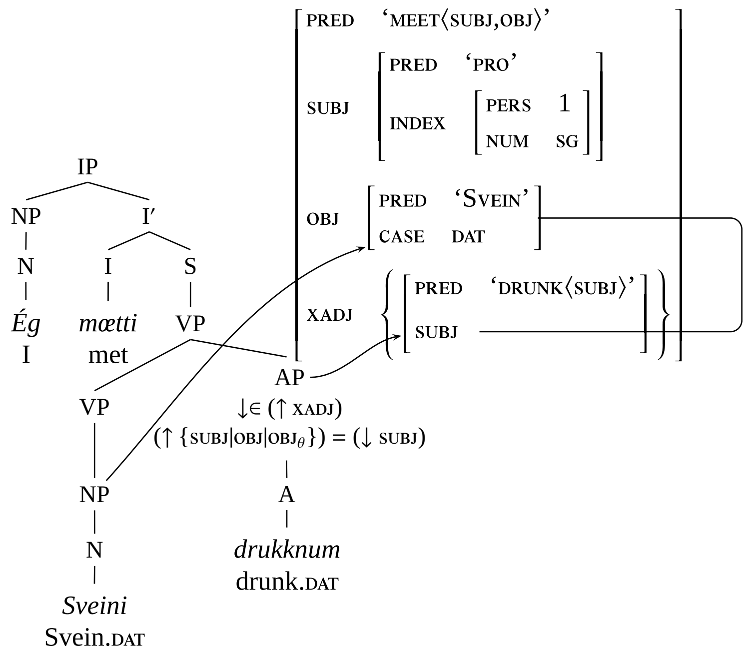
(127) *Sveini* N $(\uparrow \textsc{pred}) = \text{`}\textsc{Svein}\text{'}$
$(\uparrow \textsc{case}) = \textsc{dat}$

The c-structure and f-structure for (124) are:

[16] Andrews (1990a) attributes these examples to Rögnvaldsson (1984).

[17] It is unclear whether the XADJ is adjoined to VP in Icelandic or to some higher c-structure position. In either case, the relevant functional annotations are as shown in (125).

(128) *Ég mætti* <u>*Sveini*</u> <u>*drukknum*</u>
I met Svein.DAT drunk.DAT
'I met Svein drunk.'



8.2. Open Adjuncts and Semantic Composition

Examples of functional control in constructions involving XADJ are also found in English. We follow Bresnan (1982a) in assuming that, in a sentence like *Walking the dog, Chris saw Tracy*, the SUBJ of the participial adjunct *walking the dog* is functionally controlled by the SUBJ of the matrix clause *Chris*. We propose the following representation of the meaning of this example:

(129) *Walking the dog, Chris saw Tracy.*

during(*walk*(*Chris*, *dog*), *see*(*Chris*, *Tracy*))

Like other adjuncts, an open adjunct XADJ such as *walking the dog* combines with the clause it modifies, producing a new modified meaning of the same semantic type. In (129), the predicate *during* relates the interval at which the subordinate clause event occurs to the interval at which the main clause event occurs, and the sentence means that during the interval at which Chris was walking the dog, the event of Chris seeing Tracy occurred.[18] The f-structure and meaning constructor for (129) are:

(130) *Walking the dog, Chris saw Tracy.*

$$
s\left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{see}\langle\textsc{subj},\textsc{obj}\rangle\text{’}\\
\textsc{subj} & c\left[\begin{array}{ll}\textsc{pred} & \text{‘Chris’}\end{array}\right]\\
\textsc{obj} & t\left[\begin{array}{ll}\textsc{pred} & \text{‘Tracy’}\end{array}\right]\\
\textsc{xadj} & \left\{\; w\left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{walk}\langle\textsc{subj},\textsc{obj}\rangle\text{’}\\
\textsc{subj} & \\
\textsc{obj} & d\left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{dog}\text{’}\end{array}\right]
\end{array}\right] \;\right\}
\end{array}\right]
$$

$$\mathit{during}(\mathit{walk}(\mathit{Chris}, \mathit{dog}), \mathit{see}(\mathit{Chris}, \mathit{Tracy})) : s_\sigma$$

What linguistic element contributes the *during* predicate in this example? As discussed in Chapter 8, Section 6, meanings can be contributed not only by the words of a sentence, but also by certain syntactic configurations. In this case, the information that the event of Chris seeing Tracy occurred during the time at which Chris was walking the dog is not contributed by any of the words in either the subordinate or the main clause. Instead, the meaning is contributed by the phrase structure configuration associated with this construction: the meaning constructor associated with the *during* predicate appears on the c-structure rule associated with functionally controlled XADJ adjuncts. In other languages, this meaning might be expressed constructionally (as it is in English) or by morphological or lexical means.

The annotated c-structure tree for (129) is:

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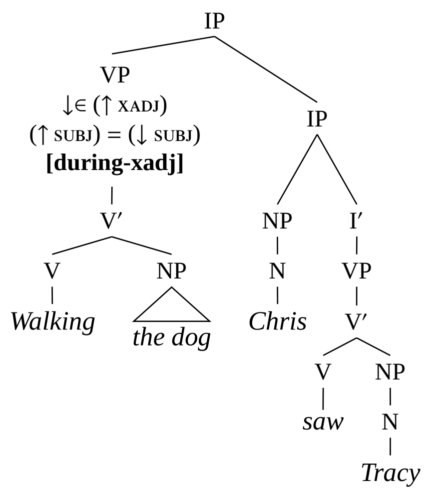
[18] This is a simplification of what is in reality a more complex temporal-aspectual relation between the event of the adjunct participle clause and that of the matrix clause. In particular, the interpretation of the relation as ‘during’ holds only when the adjunct's predicate is atelic: contrast the sentence in (129) with e.g. *Opening the book, Chris read the title page,* where the reading event follows the opening event. In this section we consider only atelic adjuncts. The semantics of tense and aspect is discussed in more detail in Chapter 8, Section 10; for an event-semantic approach to participial adjuncts which can more precisely capture the temporal-aspectual relations involved, see Haug (2008b), Bary and Haug (2011), and Lowe (2015c).

(131) *Walking the dog, Chris saw Tracy.*



The rule that gives rise to this c-structure is:

(132) $$\text{IP} \longrightarrow \begin{pmatrix} \text{VP} \\ \downarrow\in(\uparrow \textsc{xadj}) \\ (\uparrow \textsc{subj}) = (\downarrow \textsc{subj}) \\ \textbf{[during-xadj]} \end{pmatrix} \begin{pmatrix} \text{IP} \\ \uparrow=\downarrow \end{pmatrix}$$

The VP in the rule in (132) has three annotations that are crucial for our current discussion. The set-membership expression $\downarrow\in(\uparrow \textsc{xadj})$ requires the f-structure for the VP to appear as a member of the XADJ set of the mother IP. The equation $(\uparrow \textsc{subj})=(\downarrow \textsc{subj})$ means that the SUBJ of the XADJ phrase *walking the dog* is the same as the SUBJ of the matrix clause. The third annotation, **[during-xadj]**, abbreviates the following meaning constructor.

(133) **[during-xadj]** $\lambda P.\lambda Q.\lambda x.\mathit{during}(P(x), Q(x))$:
$$[(\downarrow \textsc{subj})_\sigma \multimap \downarrow_\sigma] \multimap [[(\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma] \multimap [(\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma]]$$

Instantiating the variables in this meaning constructor according to the f-structure labels in (130), we have the instantiated meaning constructor for which we reuse the label **[during-xadj]**.

(134) **[during-xadj]** $\lambda P.\lambda Q.\lambda x.\mathit{during}(P(x), Q(x))$:
$$[c_\sigma \multimap w_\sigma] \multimap [[c_\sigma \multimap s_\sigma] \multimap [c_\sigma \multimap s_\sigma]]$$

The right-hand side of this meaning constructor requires two implicational resources, $[c_\sigma \multimap w_\sigma]$ and $[c_\sigma \multimap s_\sigma]$, to produce a meaning resource $[c_\sigma \multimap s_\sigma]$. The meaning resource $[c_\sigma \multimap w_\sigma]$ represents a resource w_σ for the XADJ that has not yet combined with its subject c_σ. In other words, $[c_\sigma \multimap w_\sigma]$ is a function from the subject meaning c_σ to the XADJ meaning w_σ. Similarly, $[c_\sigma \multimap s_\sigma]$ represents a main clause meaning "missing" its subject c_σ. When both of these resources are found, a new resource $[c_\sigma \multimap s_\sigma]$ is produced, reflecting a matrix clause meaning that is modified by the participial adjunct *walking the dog*. On the left-hand side, two arguments P and Q are required; each of these arguments is applied to the subject meaning x to produce a modified meaning $\mathit{during}(P(x), Q(x))$ for the entire sentence.

The meaning constructor premises in (135) are relevant in the derivation of the meaning of this sentence; we have simplified the meaning contribution of the phrase *the dog*, representing it simply as the constant dog.

(135) Meaning constructor premises for *Walking the dog, Chris saw Tracy*:

[walk]	$\lambda x.\lambda y.\mathit{walk}(y, x)$	$: d_\sigma \multimap [c_\sigma \multimap w_\sigma]$
[dog]	dog	$: d_\sigma$
[see]	$\lambda x.\lambda y.\mathit{see}(y, x)$	$: t_\sigma \multimap [c_\sigma \multimap s_\sigma]$
[Chris]	Chris	$: c_\sigma$
[Tracy]	Tracy	$: t_\sigma$
[during-xadj]	$\lambda P.\lambda Q.\lambda x.\mathit{during}(P(x), Q(x))$	$: [c_\sigma \multimap w_\sigma] \multimap [[c_\sigma \multimap s_\sigma] \multimap [c_\sigma \multimap s_\sigma]]$

We begin by combining the premises labeled **[walk]** and **[dog]**, producing the meaning constructor labeled **[walk-dog]**.

(136) **[walk-dog]** $\lambda y.\mathit{walk}(y, \mathit{dog}) : c_\sigma \multimap w_\sigma$

This meaning constructor provides the resource $c_\sigma \multimap w_\sigma$ required by the meaning constructor **[during-xadj]**. Combining **[during-xadj]** and **[walk-dog]**, we have the meaning constructor labeled **[xadj-walk-dog]**.

(137) **[xadj-walk-dog]**

$$\lambda Q.\lambda x.\mathit{during}(\mathit{walk}(x, \mathit{dog}), Q(x)) : [[c_\sigma \multimap s_\sigma] \multimap [c_\sigma \multimap s_\sigma]]$$

Next, we combine the premises labeled **[see]** and **[Tracy]**, producing the meaning constructor **[see-Tracy]**.

(138) **[see-Tracy]** $\lambda y.\mathit{see}(y, \mathit{Tracy}) : c_\sigma \multimap s_\sigma$

This meaning constructor provides the resource needed by **[xadj-walk-dog]**. We combine **[xadj-walk-dog]** with **[see-Tracy]** to produce the meaning constructor labeled **[xadj-walk-dog-see-Tracy]**.

(139) **[xadj-walk-dog-see-Tracy]**

$$\lambda x.\mathit{during}(\mathit{walk}(x, \mathit{dog}), \mathit{see}(x, \mathit{Tracy})) : c_\sigma \multimap s_\sigma$$

Finally, we combine the meaning constructor in (139) with the remaining meaning constructor **[Chris]**, producing the following semantically complete and coherent meaning constructor, as desired.

(140) **[xadj-walk-dog-see-Tracy]**, **[Chris]** $\vdash$

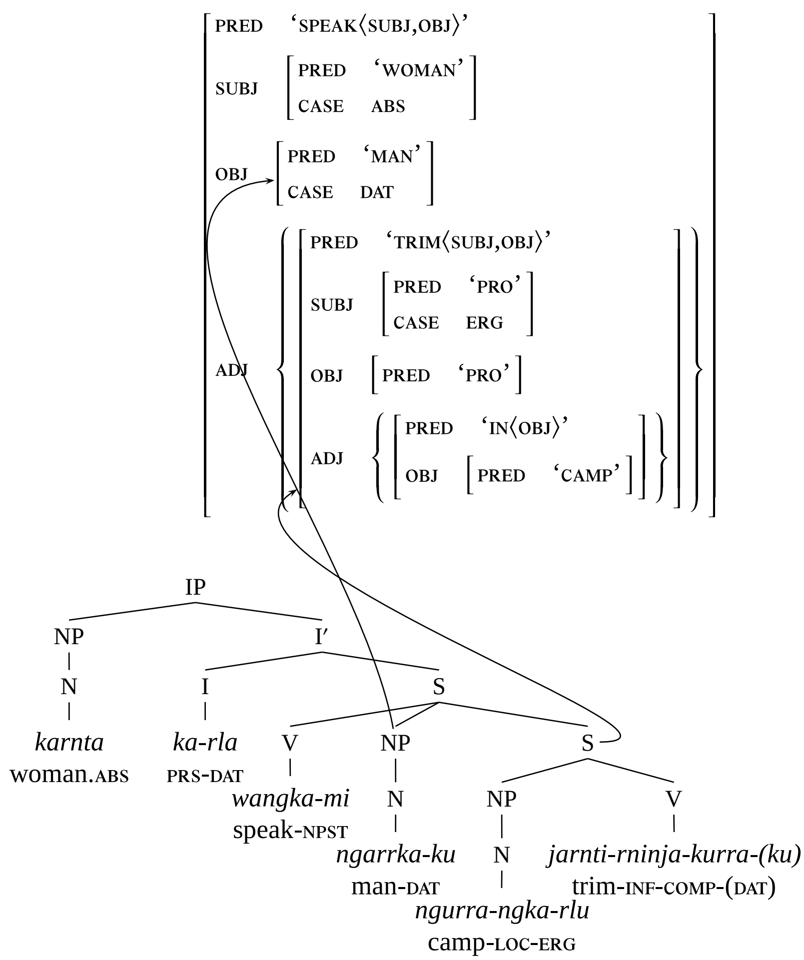
$$\mathit{during}(\mathit{walk}(\mathit{Chris}, \mathit{dog}), \mathit{see}(\mathit{Chris}, \mathit{Tracy})) : s_\sigma$$

8.3. Anaphoric Control and ADJ

Some adjuncts participate in *obligatory anaphoric control*, where an unexpressed pronominal argument of a clausal adjunct is anaphorically controlled by an argument of the matrix clause. Bresnan et al. (2016, Chapter 13) contrast participial VPs in English, which they analyze via functional control, with gerundive VPs, which are superficially similar but instead exemplify anaphoric control. Here we discuss the Warlpiri *kurra* and *karra* constructions, both of which exemplify anaphoric control. In both constructions, the SUBJ of a subordinate adjunct clause with complementizer *kurra* or *karra* is controlled by an argument of the matrix clause: the matrix SUBJ is the controller in the *karra* construction, and the matrix OBJ is the controller in the *kurra* construction.

The sentence in (141) exemplifies the *kurra*-construction, in which the OBJ of the matrix clause anaphorically controls the SUBJ of the adjunct clause.

(141) *karnta ka-rla wangka-mi ngarrka-ku [ngurra-ngka-rlu*
woman.ABS PRS-DAT speak-NPST man-DAT camp-LOC-ERG
jarnti-rninja-kurra-(ku)]
trim-INF-COMP-(DAT)
'The woman is speaking to the man (while he is) trimming it in camp.'



Simpson and Bresnan (1983) provide evidence from case agreement to demonstrate that the *kurra*-construction involves anaphoric rather than functional control and therefore that the modifying adjunct phrase *ngurra-ngka-rlu jarnti-rninja-kurra-(ku)* 'trimming it in camp' is an ADJ and not an XADJ phrase. As they point out, (141) contains an adjunct phrase *ngurra-ngka-rlu* 'in camp' which has ERG casemarking *-rlu*. Such adjunct phrases agree in case with the SUBJ of the clause they modify. Here, the phrase *ngurra-ngka-rlu* 'in camp' modifies the subordinate adjunct clause *jarnti-rninja-kurra-(ku)* 'trimming it'. Therefore, the ERG casemarking on the modifier *ngurra-ngka-rlu* 'in camp' shows that the SUBJ of the subordinate clause *jarnti-rninja-kurra-(ku)* 'trimming it' is also ERG.

However, the matrix OBJ phrase *ngarrka-ku* 'man', which anaphorically controls the subordinate SUBJ, is DAT and not ERG, in accordance with the case requirements imposed by the matrix verb *wangka-mi* 'speak'. This difference in CASE requirements between the matrix controller and the subordinate clause controllee shows that the f-structures of the controller and the controllee are different, and that anaphoric and not functional control is involved.

8.4. Controlled Adjuncts and Semantic Composition

Like the *kurra* construction, the Warlpiri *karra* construction involves anaphoric control of the subordinate clause SUBJ by an argument of the matrix clause. However, Simpson and Bresnan (1983) show that the *karra* construction contrasts with the *kurra* construction in its requirements on the controller-controllee relation: in the *karra* construction, the SUBJ of the adjunct clause is anaphorically controlled by the matrix SUBJ, not the matrix OBJ:

(142) *ngarrka ka wirnpirli-mi [karli jarnti-rninja-karra]*
man.ABS PRS whistle-NPST boomerang.ABS trim-INF-COMP
'The man is whistling while trimming a boomerang.'

In (142), the SUBJ of the adjunct phrase is anaphorically controlled by the matrix SUBJ *ngarrka* 'man', as required by the affix *-karra* on the subordinate clause verb *jarnti-* 'trim': the example means that the man is whistling while he is trimming a boomerang. Since this analysis involves anaphoric control, we represent the meaning of (142) in DRS form, as follows:

(143)
$$\begin{array}{|c|}\hline x_1, x_2, \overline{x_3} \\ \hline \mathit{during}(\begin{array}{|c|}\hline \\ \hline \mathit{boomerang}(x_2) \\ \mathit{trim}(\overline{x_3}, x_2) \\ \hline \end{array}, \begin{array}{|c|}\hline \\ \hline \mathit{man}(x_1) \\ \mathit{whistle}(x_1) \\ \hline \end{array}) \\ \hline \end{array}, \mathcal{A}(x_3) = x_1$$

The treatment of the predicate *during* in (143) is the same as in Section 8.2. It is the verbal affix *karra* which contributes the meaning *during*, specifying (approximately) that the interval corresponding to the event of trimming the boomerang occurs during the interval corresponding to the whistling event. We assume a slightly simplified representation of the noun phrase *man*, treating it as an indefinite (like *boomerang*).

The f-structure for (142) is:

(144) *ngarrka ka wirnpirli-mi [karli jarnti-rninja-karra]*
man.ABS PRS whistle-NPST boomerang.ABS trim-INF-COMP
'The man is whistling while trimming a boomerang.'

$$w\left[\begin{array}{ll}
\textsc{pred} & \text{`whistle}\langle\textsc{subj}\rangle\text{'} \\[1ex]
\textsc{subj} & m\left[\begin{array}{ll}\textsc{pred} & \text{`man'}\\ \textsc{case} & \textsc{abs}\end{array}\right] \\[2ex]
\textsc{adj} & \left\{ t\left[\begin{array}{ll}
\textsc{pred} & \text{`trim}\langle\textsc{subj,obj}\rangle\text{'}\\[1ex]
\textsc{subj} & p\left[\begin{array}{ll}\textsc{pred} & \text{`pro'}\\ \textsc{case} & \textsc{erg}\end{array}\right]\\[1ex]
\textsc{obj} & b\left[\begin{array}{ll}\textsc{pred} & \text{`boomerang'}\end{array}\right]
\end{array}\right] \right\}
\end{array}\right]$$

The lexical entry for *jarnti-rninja-karra* 'trim' is as follows.[19]

(145) *jarnti-rninja-karra* V

$$(\uparrow \textsc{pred}) = \text{`trim}\langle\textsc{subj,obj}\rangle\text{'}$$
$$\lambda y.\lambda x.\begin{array}{|c|}\hline \\ \hline \textit{trim}(x,y)\\ \hline\end{array} : (\uparrow \textsc{obj})_\sigma \multimap [(\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma]$$
$$\lambda P.\lambda Q.\begin{array}{|c|}\hline \\ \hline \textit{during}(P,Q)\\ \hline\end{array} \oplus P \oplus Q : \uparrow_\sigma \multimap [(\textsc{adj}\ \in \uparrow)_\sigma \multimap (\textsc{adj}\ \in \uparrow)_\sigma]$$
$$(\uparrow \textsc{subj pred}) = \text{`pro'}$$
$$\mathcal{R}((\uparrow \textsc{subj})_\sigma\ \textsc{index}) = (((\textsc{adj}\ \in \uparrow)\ \textsc{subj})_\sigma\ \textsc{index})$$
[pro]

The first line of this lexical entry specifies the PRED value for the verb *jarnti-rninja-karra* 'trim', and the second line provides the *trim* predicate: like any transitive verb, this verb requires a meaning for its OBJ and a meaning for its SUBJ in order to produce a meaning for the entire sentence.

The third line of this lexical entry represents part of the meaning contribution of the affix *karra*, the *during* predicate.

(146) $$\lambda P.\lambda Q.\begin{array}{|c|}\hline \\ \hline \textit{during}(P,Q)\\ \hline\end{array} \oplus P \oplus Q : \uparrow_\sigma \multimap [(\textsc{adj}\ \in \uparrow)_\sigma \multimap (\textsc{adj}\ \in \uparrow)_\sigma]$$

On the right-hand side, this meaning constructor requires a meaning resource $\uparrow_\sigma$ (to be provided by the meaning constructor in the second line of the lexical entry when its other requirements are satisfied) and a meaning $(\textsc{adj}\ \in \uparrow)_\sigma$ for the clause it modifies. When these are provided, a resource $(\textsc{adj}\ \in \uparrow)_\sigma$ results, corresponding to the modified main clause meaning. On the left-hand side, P corresponds to the meaning of the ADJ clause, and Q corresponds to the unmodified meaning of the main clause.

[19] The expression $(\textsc{adj}\ \in \uparrow)$ exemplifies inside-out functional uncertainty, discussed in Chapter 6, Section 1.3; the use of the set membership symbol $\in$ as an attribute is discussed in Chapter 6, Section 3.1.

The fourth line of this lexical entry provides the f-structure ‘PRO’ value for the PRED of the SUBJ. The fifth line establishes the antecedency relation between the s-structure INDEX value of the SUBJ of the adjunct clause, $((\uparrow \text{SUBJ})_\sigma\ \text{INDEX})$, and the s-structure INDEX value of the SUBJ of the matrix clause, $(((\text{ADJ}\ \in \uparrow)\text{SUBJ})_\sigma\ \text{INDEX})$:

(147) $\mathcal{R}((\uparrow \text{SUBJ})_\sigma\ \text{INDEX}) = (((\text{ADJ}\ \in \uparrow)\ \text{SUBJ})_\sigma\ \text{INDEX})$

Finally, the last line represents a pronominal meaning constructor **[pro]** for the SUBJ of *jarnti-rninja-karra* ‘trim’, defined as follows.

(148) **[pro]** $\lambda P. \begin{array}{|c|}\hline \overline{x_1} \\ \hline \\ \hline \end{array} \oplus P(\overline{x_1}) : \forall H.((\uparrow \text{SUBJ})_\sigma \multimap H) \multimap H$

This is identical to the meaning **[pro]** used in the analyses of obligatory and arbitrary anaphoric control provided previously. Instantiating this meaning constructor according to the f-structure labels in (144), we obtain the meaning constructor in (149), for which we reuse the label **[pro]**.

(149) **[pro]** $\lambda P. \begin{array}{|c|}\hline \overline{x_1} \\ \hline \\ \hline \end{array} \oplus P(\overline{x_1}) : \forall H.(p_\sigma \multimap H) \multimap H$

The meaning constructors in (150) are relevant in the analysis of example (142).

(150) Meaning constructor premises for *ngarrka ka wirnpirli-mi karli jarnti-rninja-karra*:

[whistle]	$\lambda x. \begin{array}{|c|}\hline \\ \hline \textit{whistle}(x) \\ \hline \end{array}$	$: m_\sigma \multimap w_\sigma$
[man]	$\lambda P. \begin{array}{|c|}\hline x_1 \\ \hline \textit{man}(x_1) \\ \hline \end{array} \oplus P(x_1)$	$: \forall H.(m_\sigma \multimap H) \multimap H$
[trim]	$\lambda y.\lambda x. \begin{array}{|c|}\hline \\ \hline \textit{trim}(x, y) \\ \hline \end{array}$	$: b_\sigma \multimap [p_\sigma \multimap t_\sigma]$
[during]	$\lambda P.\lambda Q. \begin{array}{|c|}\hline \\ \hline \textit{during}(P, Q) \\ \hline \end{array} \oplus P \oplus Q$	$: t_\sigma \multimap [w_\sigma \multimap w_\sigma]$
[pro]	$\lambda P. \begin{array}{|c|}\hline \overline{x_1} \\ \hline \\ \hline \end{array} \oplus P(\overline{x_1})$	$: \forall H.(p_\sigma \multimap H) \multimap H$
[boomerang]	$\lambda P. \begin{array}{|c|}\hline x_1 \\ \hline \textit{boomerang}(x_1) \\ \hline \end{array} \oplus P(x_1)$	$: \forall H.(b_\sigma \multimap H) \multimap H$

In order to obtain the correct reading for this sentence, it is necessary first to introduce hypothetical meanings for the arguments of the main verb (see Chapter 8, Section 8.1.4).[20] We therefore make use of the hypothetical meaning constructors $a : [p_\sigma]$ and $b : [b_\sigma]$ to obtain a complete meaning for the predicate *trim*, labeled **[trim-ab]**.

[20] This is necessary in order to ensure that the predicate *during* does not scope over the discourse referents x_1, x_2, and $\overline{x_3}$.

(151) **[trim-ab]** $\begin{array}{|c|}\hline \\ \hline \textit{trim}(a,b) \\ \hline\end{array} : t_\sigma$

We likewise hypothesize the meaning constructor $c : [m_\sigma]$ for the verb *whistle*, to produce the meaning constructor **[whistle-c]**.

(152) **[whistle-c]** $\begin{array}{|c|}\hline \\ \hline \textit{whistle}(c) \\ \hline\end{array} : w_\sigma$

The predicate *during* can then apply to these two propositions, to yield the meaning constructor labeled **[whistle-trim-adj-abc]**.[21]

(153) **[whistle-trim-adj-abc]** $\begin{array}{|c|}\hline \\ \hline \textit{during}(\begin{array}{|c|}\hline \\ \hline \textit{trim}(a,b) \\ \hline\end{array}, \begin{array}{|c|}\hline \\ \hline \textit{whistle}(c) \\ \hline\end{array}) \\ \hline\end{array} : w_\sigma$

It is now necessary to discharge the hypotheses introduced above, yielding the meaning constructor labeled **[whistle-trim-adj]**.

(154) **[whistle-trim-adj]** $\lambda x.\lambda y.\lambda z.\begin{array}{|c|}\hline \\ \hline \textit{during}(\begin{array}{|c|}\hline \\ \hline \textit{trim}(z,y) \\ \hline\end{array}, \begin{array}{|c|}\hline \\ \hline \textit{whistle}(x) \\ \hline\end{array}) \\ \hline\end{array} : m_\sigma \multimap [b_\sigma \multimap [p_\sigma \multimap w_\sigma]]$

This meaning constructor is of the correct form for the meaning constructor **[man]** to apply to it; combining these produces the meaning constructor **[man-w-t-a]**.

(155) **[man-w-t-a]** $\lambda y.\lambda z.\begin{array}{|c|}\hline x_1 \\ \hline \textit{during}(\begin{array}{|c|}\hline \\ \hline \textit{trim}(z,y) \\ \hline\end{array}, \begin{array}{|c|}\hline \\ \hline \textit{man}(x_1) \\ \textit{whistle}(x_1) \\ \hline\end{array}) \\ \hline\end{array} : b_\sigma \multimap [p_\sigma \multimap w_\sigma]$

Now the meaning constructor **[boomerang]** can be applied to the meaning constructor **[man-w-t-a]**, producing the meaning constructor **[man-bmr-w-t-a]**.

[21] We simplify here by treating *during* as a relation between DRSs, which incorrectly allows for the possibility for discourse referents to scope inside the DRS arguments of *during*. The problem would disappear if we adopted a more sophisticated analysis in which *during* is a relation between event variables (as introduced in Chapter 8, Section 10), since there would then be no subordinate DRSs as arguments to *during*.

(156) **[man-bmr-w-t-a]** $\lambda z. \begin{array}{|c|}\hline x_1, x_2 \\ \hline \\ \mathit{during}(\begin{array}{|c|}\hline \\ \hline \mathit{boomerang}(x_2) \\ \mathit{trim}(z, x_2) \\ \hline \end{array}, \begin{array}{|c|}\hline \\ \hline \mathit{man}(x_1) \\ \mathit{whistle}(x_1) \\ \hline \end{array}) \\ \\ \hline \end{array} : p_\sigma \multimap w_\sigma$

The resulting meaning constructor is of the correct form for the meaning constructor **[pro]** to be applied to it, producing a coherent meaning for the clause.

(157) **[man-bmr-w-t-a]** $\begin{array}{|c|}\hline x_1, x_2, \overline{x_3} \\ \hline \\ \mathit{during}(\begin{array}{|c|}\hline \\ \hline \mathit{boomerang}(x_2) \\ \mathit{trim}(\overline{x_3}, x_2) \\ \hline \end{array}, \begin{array}{|c|}\hline \\ \hline \mathit{man}(x_1) \\ \mathit{whistle}(x_1) \\ \hline \end{array}) \\ \\ \hline \end{array} : w_\sigma$

Finally, the constraint in (147) enforces an antecedency relation between the subject of the adjunct clause and the subject of the matrix clause. We therefore augment the meaning constructor in (157) with a specification of $\mathcal{A}$.

(158) $\begin{array}{|c|}\hline x_1, x_2, \overline{x_3} \\ \hline \\ \mathit{during}(\begin{array}{|c|}\hline \\ \hline \mathit{boomerang}(x_2) \\ \mathit{trim}(\overline{x_3}, x_2) \\ \hline \end{array}, \begin{array}{|c|}\hline \\ \hline \mathit{man}(x_1) \\ \mathit{whistle}(x_1) \\ \hline \end{array}) \\ \\ \hline \end{array}, \mathcal{A}(x_3) = x_1 : w_\sigma$

In this way, constraints on the antecedent of the unexpressed pronominal subject of the ADJ clause are appropriately enforced.

9. FURTHER READING AND RELATED ISSUES

The syntax of functional and anaphoric control has been a central topic of LFG research from the inception of the theory; besides the work discussed in this chapter, important early work exploring the nature of control crosslinguistically was done by Neidle (1982), Andrews (1982), and Mohanan (1983).

Research in LFG generally assumes that the open complement in a functional control construction bears the grammatical function XCOMP and that no other grammatical function is an open function. Arka and Simpson (1998, 2008) provide evidence that this assumption cannot be universally maintained. In English and many other languages, the controller in an equi or raising construction can bear the SUBJ role, while the controlled clause can be an XCOMP; alternatively, in some languages but not in English, OBJ controllers are possible with open SUBJ complements. In the Balinese equivalent of a sentence like *Chris wants to leave*, then, the controller *Chris* can bear the OBJ function, with *to leave* bearing the SUBJ function. This situation counterexemplifies previous claims about the syntactic role of the controller and the controlled clause: Jacobson (1990) claims that the controller in a raising construction must be higher on the grammatical function hierarchy than the controllee, precluding an analysis of the open complement in a Balinese control construction as a SUBJ. As Arka and Simpson (1998, 2008) show, control constructions in Balinese do not obey this generalization.

This is not the only proposal to extend the inventory of open grammatical functions. As discussed in Section 1.2, Falk (2005) argues that alongside XCOMP it is necessary to distinguish XOBJ$_\theta$ and XOBL$_\theta$.

One type of control construction not discussed in this chapter is so-called 'possessor raising':

(159) *She kissed him on the cheek.*

In this example, the OBJ of the verb, *him*, also functions as the possessor of the OBL OBJ *the cheek*. Lødrup (2009) discusses possessor raising constructions in Norwegian, analyzing them in terms of functional control. Further discussion of control structures in Norwegian is provided in Lødrup (2001, 2002a,b, 2008b, 2017a,b), among others.

The analysis of predicative participial and adjectival adjuncts in terms of functional control, as presented in Section 8.1 of this chapter, has been widely adopted. Whether attributively used participial adjuncts should be analyzed in terms of functional or anaphoric control is more controversial. Authors who argue for the former position include Haug and Nikitina (2012, 2016) and Spencer (2015); Lowe (2015c, 2017a) argues for the latter.

The analysis of auxiliary verb constructions in English and other languages is also a matter for debate. Falk (2003, 2008) discusses the English auxiliary system, and argues that a uniform analysis is not possible: some auxiliaries in English must be analyzed as raising verbs, while others do not contribute a PRED but merely contribute features to the f-structure headed by the lexical verb. Patejuk and Przepiórkowski (2014) take up this question with regard to the Polish passive, arguing that it should be treated in terms of raising. Butt and Lahiri (2013) contrast the properties of auxiliary constructions with those of complex predicate constructions in a diachronic perspective.

The diachronic development of control constructions has been investigated by Barron (1997, 2001), Lowe (2015c), and Lødrup (2017a), among others.

16

COORDINATION

In this chapter, we examine constructions involving coordination. In Section 1, we examine the syntax of simple clausal coordination. Section 2 discusses coordinate structures involving verbs and other argument-taking predicates. Section 3 discusses f-structure features and their behavior in coordinate structures, with a particular focus on the distinction between *distributive* and *nondistributive* features introduced in Chapter 6, Section 3.2. Section 4 presents the theory of nonconstituent coordination, and Section 5 discusses unlike coordination. Section 6 discusses coordination patterns crosslinguistically, and introduces rule macros for coordinate structures.

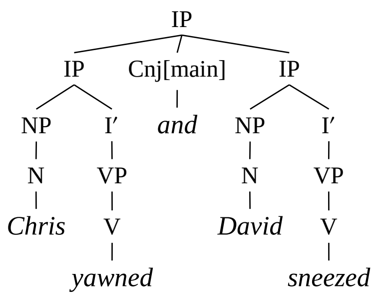
In Section 7, we turn to an examination of the semantics of clausal, predicate, and verb coordination. In some cases, such as clausal coordination, simple conjunction of the meanings of the conjuncts is involved. In other cases involving sharing of dependents, the resource-sensitive nature of our glue language becomes an issue, and a theory of resource sharing is required.

Section 8 examines noun phrase coordination and the syntactic and semantic properties of coordinated noun phrases, which may include person, number, and gender features. Semantically, noun phrase coordination differs from clausal or predicate coordination in that it involves group formation, and so we also briefly discuss the semantics of plurals, including conjoined quantifiers.

1. CLAUSAL COORDINATION

Coordination was first examined in an LFG setting by Bresnan et al. (1985b), and the formal properties of coordination were explored in detail by Kaplan and Maxwell (1988b). We begin our discussion with the simple case of clausal coordination, as described by Kaplan and Maxwell (1988b). Kaplan and Maxwell propose a constituent structure like (1) for coordinated clauses like *Chris yawned and David sneezed*:

(1) *Chris yawned and David sneezed.*



As this c-structure shows, we do not treat coordinate structures as X′-theoretic phrases of category CnjP, headed by Cnj, as proposed by Johannessen (1998) and others. Rather, a coordinate structure is a non-X′-theoretic structure in which the mother node inherits the category of its conjuncts, so that a coordinate structure with IP conjuncts is a phrase of category IP. Borsley (2005) and Hristov (2012) present convincing arguments in favor of the view adopted here, and against the X′-theoretic CnjP view.

There is no limit to the number of conjuncts in a coordinate structure; therefore, as discussed in Chapter 2, Section 4.4, a coordinate f-structure is represented as a set whose members are the f-structures of the individual conjuncts. The c-structure in (1) corresponds to this f-structure:

(2) *Chris yawned and David sneezed.*

$$\left\{ \begin{array}{l} \left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'} \\ \textsc{subj} & \left[ \begin{array}{ll} \textsc{pred} & \text{`}\textsc{Chris}\text{'} \end{array} \right] \end{array} \right] \\ \\ \left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{sneeze}\langle\textsc{subj}\rangle\text{'} \\ \textsc{subj} & \left[ \begin{array}{ll} \textsc{pred} & \text{`}\textsc{David}\text{'} \end{array} \right] \end{array} \right] \end{array} \right\}$$

The c-structure and f-structure in (1) and (2) are constrained by the rule in (3) for IP coordination. We adopt the complex c-structure category Cnj[main] (with parameter main) for conjunctions like *and*; below, we introduce the category Cnj[pre] for preconjunctions such as *both* in *both Chris and David*. The preliminary rule in (3) does not account for certain aspects of the f-structure of coordinate structures, including features contributed by the conjunction *and*; in Section 3, we provide a coordination rule which incorporates this aspect of the syntax of coordinate structures.

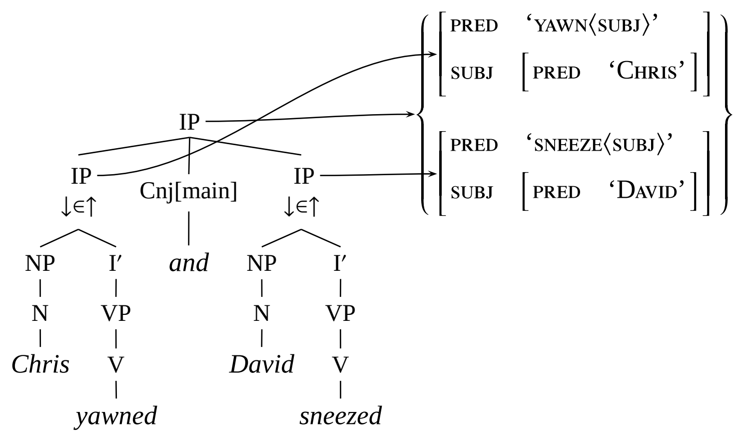
(3) Preliminary rule for IP coordination, to be amended

$$\begin{array}{lllll} \text{IP} & \longrightarrow & \text{IP}^{+} & \text{Cnj[main]} & \text{IP} \\ & & \downarrow\in\uparrow & & \downarrow\in\uparrow \end{array}$$

This rule makes use of the *Kleene plus operator* +, which licenses one or more occurrences of IP. Thus, this rule allows a coordinate IP to consist of one or more IPs, followed by a conjunction, followed by the final IP conjunct.

The functional annotations on this rule use the set-membership relation symbol ∈ to specify that each f-structure corresponding to an IP conjunct is a member of the set of f-structures corresponding to the mother IP; *set descriptions* are discussed in more detail in Chapter 6, Section 3. The diagram in (4) shows the relation between the c-structure and the f-structure of the example under discussion:

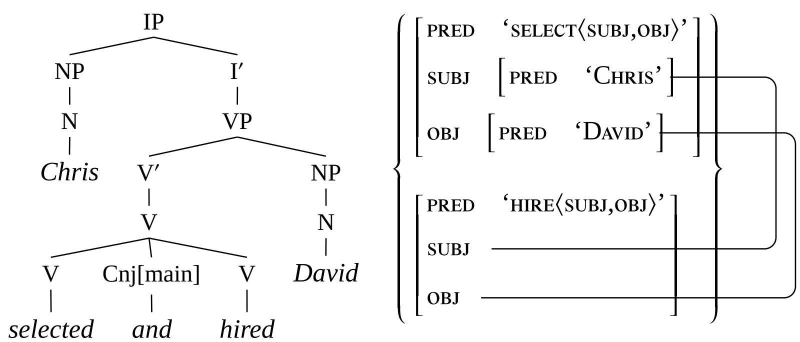
(4) *Chris yawned and David sneezed.*



2. PREDICATE COORDINATION

When unsaturated predicates are coordinated, the situation is more complex: coordinated verbs often share some arguments, and Completeness and Coherence requirements must be satisfied for each verb. In (5), the verbs *selected* and *hired* are transitive, and so to meet Completeness and Coherence requirements each must have a SUBJ and an OBJ. In the c-structure and f-structure shown in (5), this requirement is met; for both verbs, *Chris* is the SUBJ, and *David* is the OBJ.

(5) *Chris selected and hired David.*



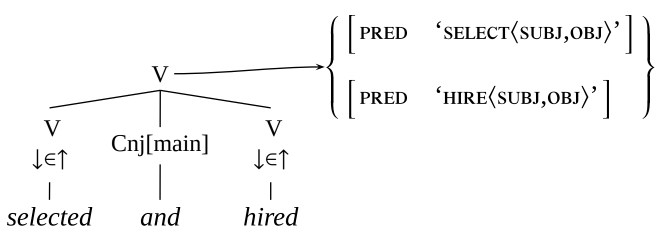
We propose this preliminary phrase structure rule for verb coordination:

(6) Preliminary rule for V coordination, to be amended

$$\mathrm{V} \longrightarrow \underset{\downarrow\in\uparrow}{\mathrm{V}^{+}} \quad \mathrm{Cnj[main]} \quad \underset{\downarrow\in\uparrow}{\mathrm{V}}$$

Given the rule in (6), the c-structure and f-structure for the coordinated verbs *selected and hired* are:

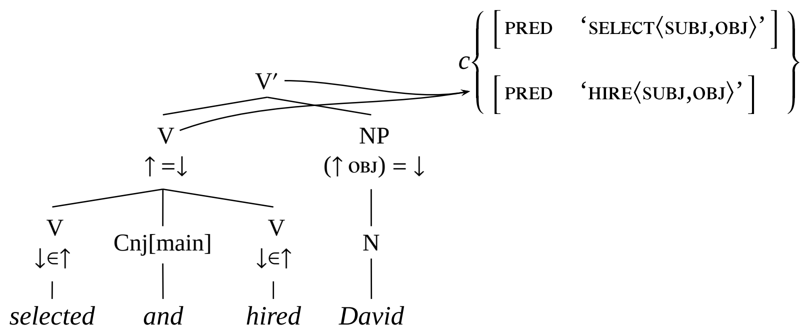
(7) *selected and hired*



Both of these verbs are transitive, requiring a SUBJ and an OBJ. In the example under discussion, the coordinate V is the head of V′, and the f-structure corresponding to V′ (with OBJ structure not yet included) is the set labeled *c*, as the annotations in (8) indicate.

(8) *selected and hired David*

F-structure not including structure contributed by *David*:



In (8), the equation on the NP node dominating *David* refers to the f-structure corresponding to the V′ node — the set c — and requires the f-structure for *David* to be the OBJ of that set. These requirements are summarized in (9), where the f-structure for *David* is labeled d, and the annotation on the NP node is instantiated to (c OBJ) = d:

(9) *selected and hired David*

$$c\left\{\begin{array}{l}\left[\text{PRED} \quad \text{`SELECT}\langle\text{SUBJ,OBJ}\rangle\text{'}\right] \\ \\ \left[\text{PRED} \quad \text{`HIRE}\langle\text{SUBJ,OBJ}\rangle\text{'}\right]\end{array}\right\}$$

$$d\left[\text{PRED} \quad \text{`DAVID'}\right]$$

$$(c\ \text{OBJ}) = d$$

Bresnan et al. (1985b) and Dalrymple and Kaplan (2000) provide a definition of function application to sets that allows us to interpret an equation like (c OBJ) = d when c is a set: in such a situation, d is required to be the OBJ of each member of the set c. This is because governable grammatical functions like OBJ are *distributive features*, as defined in (190) of Chapter 2, Section 5.8 and (64) of Chapter 6, Section 3.2, and repeated here:[1]

(10) Nondistributive features: INDEX, ADJ, CONJ, PRECONJ

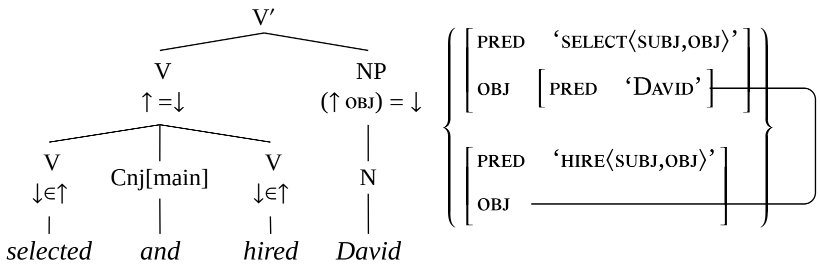
Distributive features: all other features, including PRED and the governable grammatical functions

(11) If a is a *distributive* feature and s is a set of f-structures, then $(s\ a) = v$ holds if and only if $(f\ a) = v$ for all f-structures f that are members of the set s.

Thus, the constraints in (9) entail that d is the OBJ of each f-structure in c:

[1]Peterson (2004a, page 655) provides a definition similar to (11), but restricted to situations in which a is a grammatical function: in other words, for Peterson, the only distributive features are grammatical functions.

(12) *selected and hired David*



By the same reasoning, *Chris* is the SUBJ of the set *c* in (5) and is thus the SUBJ of each member of *c*, as shown in (5).

Peterson (2004a) observes that the treatment of grammatical functions as distributive features nicely accounts for this pattern:

(13) a. *Kate faxed and emailed the results to Paul.*

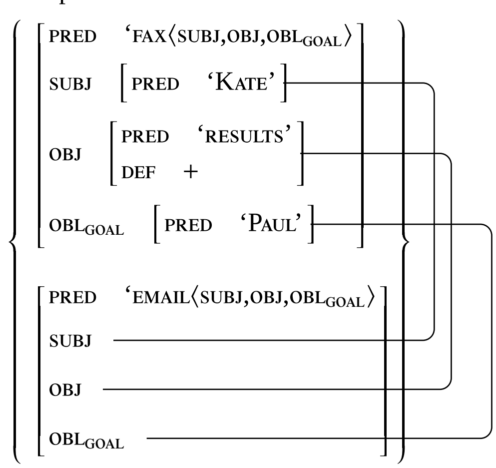
b. **Kate faxed and disliked the results to Paul.*

c. **Kate faxed the results to Paul and Kate disliked the results to Paul.*

The verbs *fax* and *email* require a SUBJ (*Kate*), an OBJ (*the results*), and an OBL_{GOAL} (*to Paul*), and these arguments are shared in the coordinate structure in (13a), as shown in (14a). In contrast, (13b) is ungrammatical for the same reason that (13c) is ungrammatical: *dislike* requires an OBJ but not an OBL_{GOAL}. The incoherent f-structure for (13b) is shown in (14b).

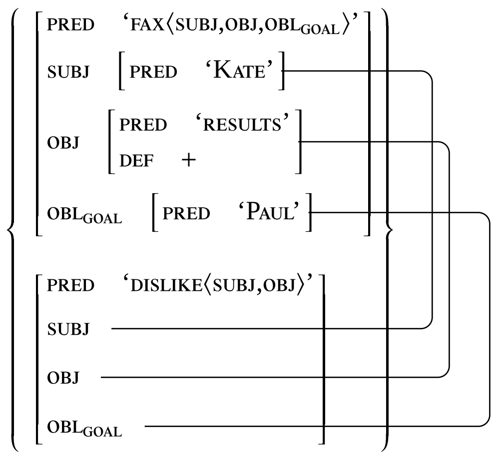
(14) a. *Kate faxed and emailed the results to Paul.*

Complete and coherent f-structure:



b. **Kate faxed and disliked the results to Paul.*

Incoherent f-structure (*dislike* does not govern OBL_{GOAL}):



As Frank (2006) shows, the classification of grammatical functions as distributive features also underpins a straightforward account of the German asymmetric coordination construction, also known as SGF coordination (Subject Gap in Finite/Fronted constructions; Wunderlich 1988). In these constructions, one of the dependents (SUBJ or a member of the DIS set) appears in the initial conjunct, but is shared across all of the conjuncts of the coordinate structure. This is shown in (15), where the subject *der Jäger* 'the hunter' appears in the first conjunct, but is interpreted as the subject of both the first and the second conjunct (Wunderlich 1988, page 289). Other arguments are not shared in this way: for example, the locative phrase *in den Wald* is associated only with the initial conjunct.

(15) *[In den Wald ging der Jäger] und [fing einen Hasen].*
into the forest went the hunter and caught a rabbit
'The hunter went into the forest and caught a rabbit.'

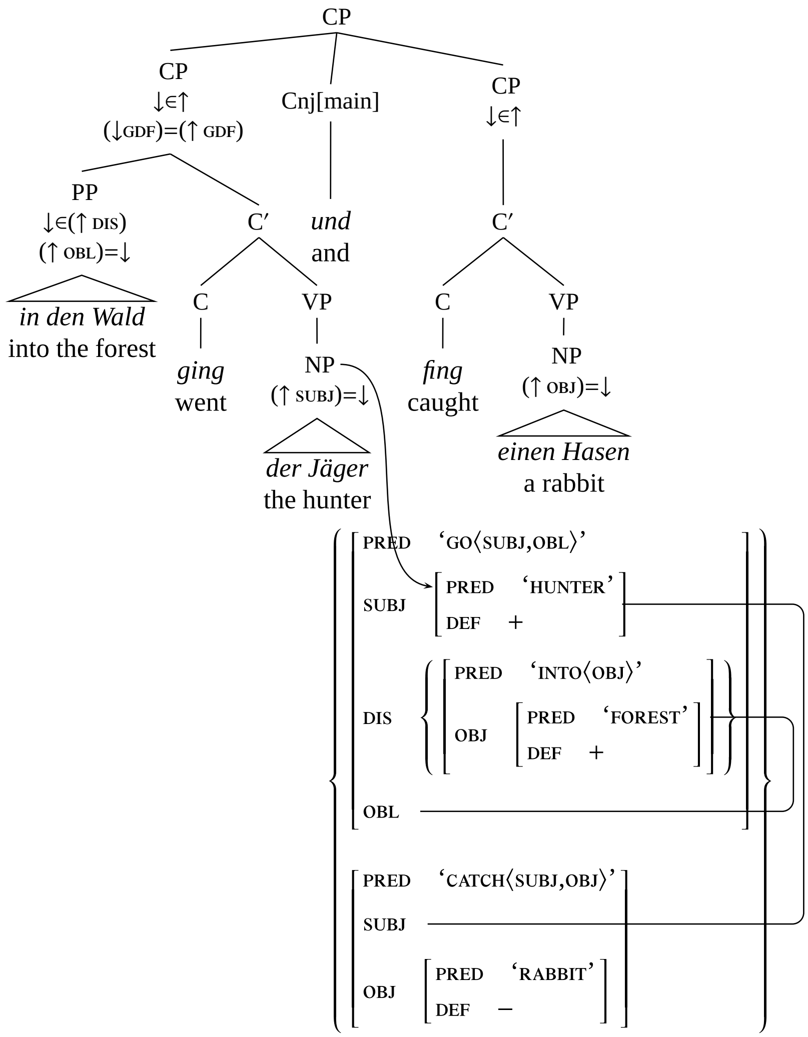
Frank (2006) analyzes these constructions by means of asymmetric projection of either SUBJ or a member of the DIS set from the first conjunct. She defines the abbreviatory symbol GDF as a disjunction including SUBJ and DIS, and adds an optional constraint to associate the GDF in the first clause with the coordinate structure as a whole. Since both SUBJ and DIS are distributive, the result is that the GDF distributes to each conjunct:

(16) $\text{GDF} \equiv \{\text{SUBJ}|\text{DIS} \in\}$

$$\begin{array}{llll} \text{CP} \longrightarrow & \text{CP} & \text{Cnj} & \text{CP} \\ & \downarrow\in\uparrow & & \downarrow\in\uparrow \\ & ((\downarrow\text{GDF})=(\uparrow\text{GDF})) & & \end{array}$$

The annotated phrase structure and f-structure for (15) are shown in (17), with the subject *der Jäger* 'the hunter' distributed over both conjuncts:

(17) *[In den Wald ging der Jäger] und [fing einen Hasen].*
Into the forest went the hunter and caught a rabbit
'The hunter went into the forest and caught a rabbit.'



This allows for the correct c-structural and f-structural analysis of such examples, with only a minimal addition to the annotation on the standard c-structure rule for CP coordination.

Frank (2006) also discusses the discourse-functional properties of this construction, showing that the special properties of this construction are related to general discourse subordination effects also found in modal subordination (Frank 1997); this provides an explanation of some of the other syntactic, semantic, and discourse properties of the construction.

3. SYNTACTIC PROPERTIES OF COORDINATE STRUCTURES

Coordinate structures are special in that the coordinate structure as a whole often has its own properties, distinct from the properties of its elements. The syntactic features that a set of f-structures can have are *nondistributive features*. The behavior of nondistributive features, defined in (64) of Chapter 6, Section 3.2, is repeated here:

(18) If a is a *nondistributive* feature, then $(f\ a) = v$ holds if and only if the pair $\langle a, v\rangle \in f$.

We now expand our treatment of conjunction to allow preconjunctions such as *both*, *either*, and *neither*. Notice that the preconjunction *both* is allowed only for some categories: V, NP, PP, and AP, for example, but not N:[2]

(19) a. *Chris both [made] and [ate] a sandwich.*

b. *Both [the man] and [the woman] sneezed.*

c. *I looked both [under the table] and [in the box].*

d. *David is both [tall] and [thin].*

e. **The both [sandwich] and [soup] are cold.*

We propose the following lexical entries for *both* and *and*:

(20)	*both*	Cnj[pre]	$(\uparrow \text{PRECONJ}) = \text{BOTH}$
			$(\uparrow \text{CONJ}) =_c \text{AND}$
	and	Cnj[main]	$(\uparrow \text{CONJ}) = \text{AND}$

The features PRECONJ and CONJ are classified as nondistributive features. Treating the CONJ feature as a nondistributive feature of the coordinate structure also ensures that different conjunctions do not appear in the same coordinate structure: *Chris and David or Tracy* may not be treated as a single coordinate structure with three conjuncts, but must be analyzed as nested coordination, either *Chris and [David or Tracy]* or *[Chris and David] or Tracy*. The second line of the lexical entry for *both* contains a constraining equation ensuring that *both* does not appear with conjunctions other than *and*, allowing *both tall <u>and</u> thin* and disallowing **both tall <u>or</u> thin*.

The rule in (21) permits the analysis of coordinated verbs with a preconjunction (*Chris both yawned and sneezed*), and associates the information contributed

[2] Huddleston and Pullum (2002, Chapter 15) provide more discussion of preconjunctions and what they call correlative coordination: *both...and*, *either...or*, *neither...nor*. Constraints on this construction are complex: for example, although *both* is not permitted in IP coordination, *either* is permitted:

(a) **Both [it is raining] and [the sun is shining].*

(b) *Either [it is raining] or [the sun is shining].*

We leave a full treatment of the syntax of correlative coordination for future work.

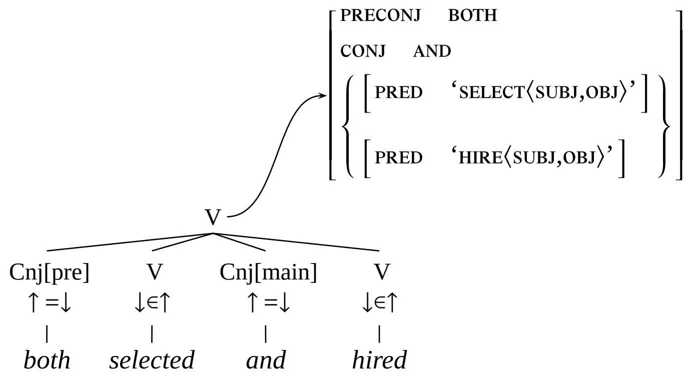
by the conjunction and any preconjunctions like *both* or *either* with the f-structure for the coordinate phrase.

(21) Rule for V coordination including preconjunction:

$$\text{V} \quad \longrightarrow \quad \left(\begin{array}{c}\text{Cnj[pre]}\\ \uparrow=\downarrow\end{array}\right) \quad \begin{array}{c}\text{V}^{+}\\ \downarrow\in\uparrow\end{array} \quad \begin{array}{c}\text{Cnj[main]}\\ \uparrow=\downarrow\end{array} \quad \begin{array}{c}\text{V}\\ \downarrow\in\uparrow\end{array}$$

Given the lexical entries in (20) and the rule in (21), the c-structure and f-structure for the phrase *both selected and hired* are:

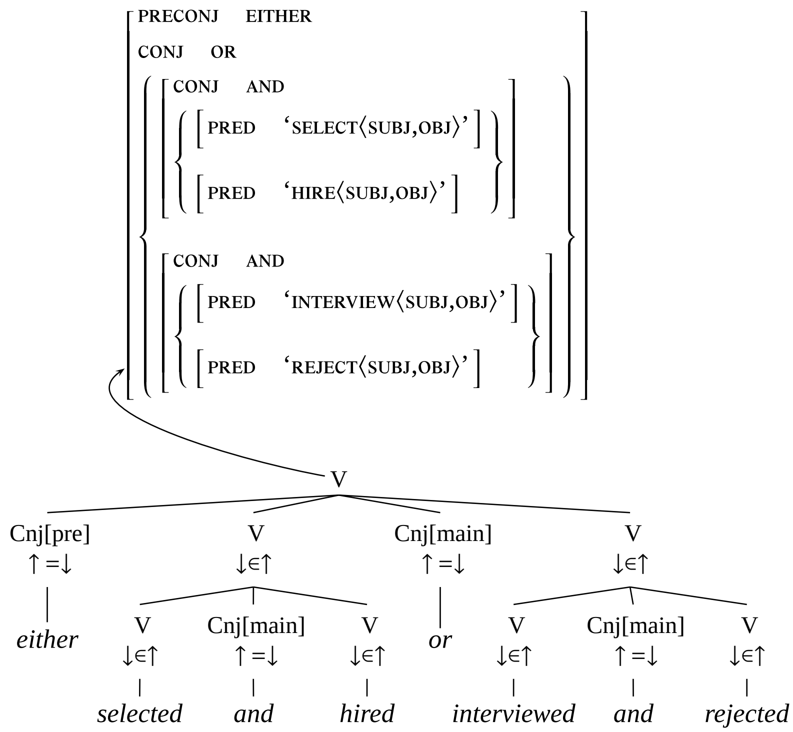
(22) *both selected and hired*



In (22), the PRECONJ and CONJ features are attributes of the coordinate structure, as required.

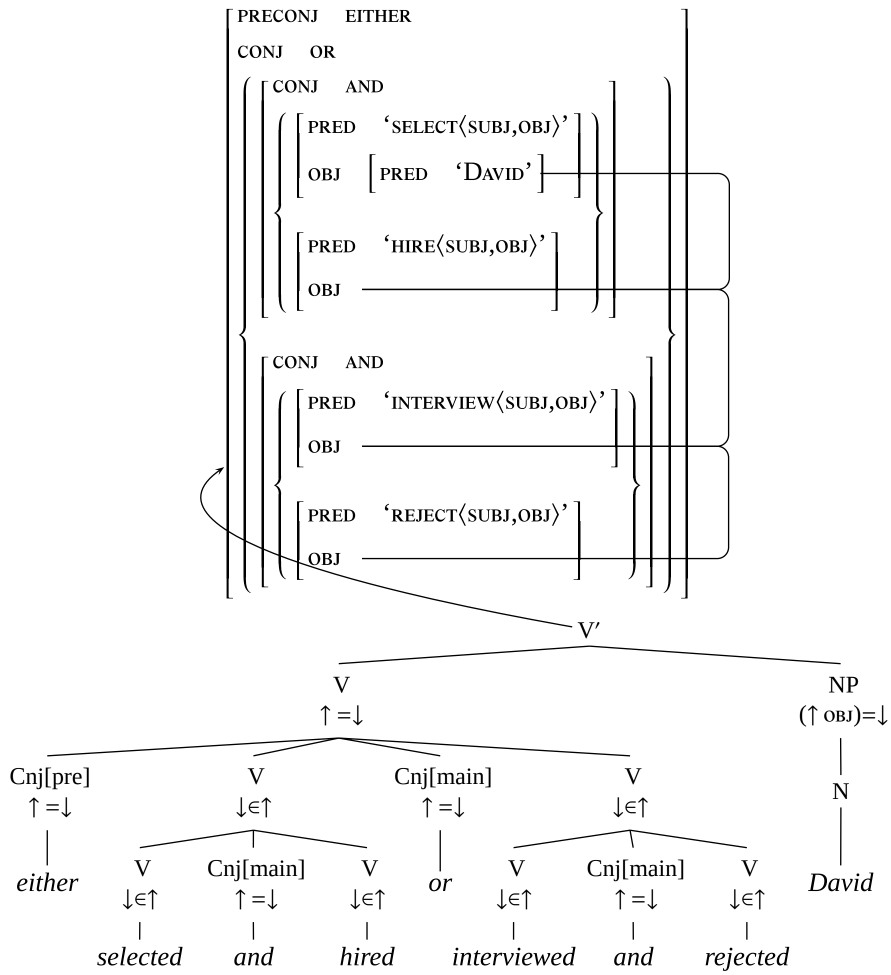
The coordination rule in (21) also permits more complex nested coordinate structures like *either [selected and hired] or [interviewed and rejected]*, which has the following c-structure and f-structure:

(23) *either selected and hired or interviewed and rejected*



As we have seen, grammatical functions are distributive; thus, a verbal dependent appearing outside this complex coordinate structure distributes to the innermost conjuncts, as shown in (24), where *David* is the OBJ of each verb.

(24) *either selected and hired or interviewed and rejected David*



4. NONCONSTITUENT COORDINATION

Coordination has often been considered a reliable indicator of constituenthood; for example, as discussed in Chapter 3, Section 1, Radford (2009) proposes that a string of words is a constituent if “it can be coordinated with another similar constituent.” However, constructions involving nonconstituent coordination show that the situation is more complex. Strings that are clearly not phrase structure constituents can be coordinated:

(25) *David introduced [[Chris] [to Tracy]] and [[Matty] [to Ken]].*

In (25), the sequence *Chris to Tracy* is not a phrase structure constituent; nevertheless, it can be coordinated with the sequence *Matty to Ken*, which is not a constituent either.

Maxwell and Manning (1996) propose a theory of nonconstituent coordination that accounts for the grammaticality of examples like (25). Their account has its basis in Wasow's Generalization.

(26) Wasow's Generalization (Pullum and Zwicky 1986):

> If a coordinate structure occurs in some position in a syntactic representation, each of its conjuncts must have syntactic feature values that would allow it individually to occur in that position.

According to Wasow's Generalization, (25) is acceptable because both *Chris to Tracy* and *Matty to Ken* constitute valid completions of a VP constituent beginning with *introduced*. Maxwell and Manning's theory captures this generalization by allowing phrase structure rules to be split, and rules of coordination to refer to the partial constituents that are described by these partial rules. Building on the approach of Maxwell and Manning (1996), Brun (1996a,b) develops a detailed analysis of coordination in French, and Forst and Rohrer (2009) and Kuhn et al. (2010) explore nonconstituent coordination and right node raising in German.

4.1. Constituent Structure Constraints

To illustrate Maxwell and Manning's approach, we assume the following simplified phrase structure rule for the English VP:

(27) $\text{VP} \longrightarrow \text{V} \;\; \text{NP} \;\; \text{PP}$

Maxwell and Manning propose that we can think of the right side of this rule as being divided into two portions, which we will call VP-*x* for the first part and *x*-VP for the second part:

(28) $\text{VP} \longrightarrow \text{VP-}x \quad x\text{-VP}$

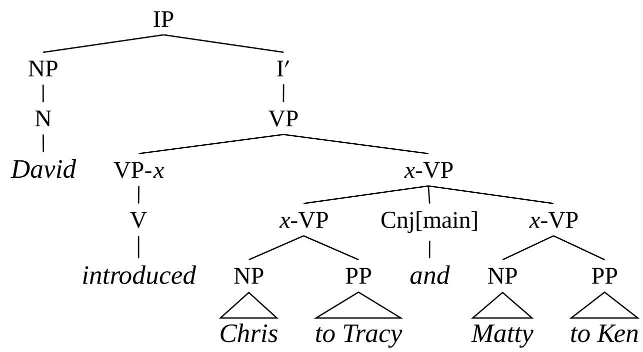
To analyze (25), we assume that the first half of the VP rule analyzes V, and the second half analyzes the sequence NP PP; for other constructions, a different split of the rule might be necessary.

(29) $\text{VP-}x \longrightarrow \text{V}$

$x\text{-VP} \longrightarrow \text{NP} \;\; \text{PP}$

Crucially, rules of coordination can refer to the partial phrase structure constituents that result from splitting rules in this way. This allows the following c-structure analysis of (25):

(30) *David introduced Chris to Tracy and Matty to Ken.*



On Maxwell and Manning's theory, any phrase structure rule can be broken up into two or more parts in this way. However, the only rules that can refer to these partial phrase structure constituents are rules of coordination. Therefore, the partial constituents that result from rule splitting play no other role in the grammar besides their role in the analysis of nonconstituent coordination.

In analyzing more complex examples, a c-structure rule may be broken into more than two pieces. For the purposes of this example, we assume this VP rule:

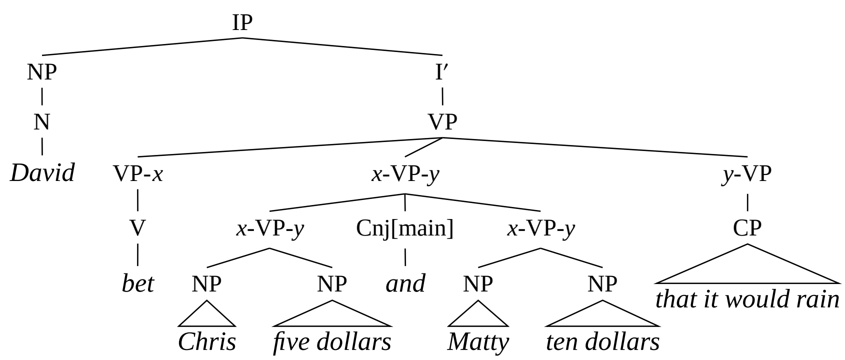
(31) VP $\longrightarrow$ V NP NP CP

We then break the VP into three parts. The first part of the VP, VP-*x*, analyzes V; the second part, *x*-VP-*y*, analyzes the sequence NP NP; and the third part, *y*-VP, analyzes CP:

(32) VP $\longrightarrow$ VP-*x* *x*-VP-*y* *y*-VP
VP-*x* $\longrightarrow$ V
x-VP-*y* $\longrightarrow$ NP NP
y-VP $\longrightarrow$ CP

These rules allow an analysis of the following example, in which there is shared material both before and after the coordinate structure:

(33) *David bet Chris five dollars and Matty ten dollars that it would rain.*



Other examples show greater degrees of complexity. Examples (31) and (33) involve partial constituents that are all dominated by a single mother node; Maxwell and Manning also discuss examples in which more than one rule is involved in the split, treating these examples by the use of a stack of partial constituents that must be combined in a compatible way.

In formal terms, Maxwell and Manning (1996) state their proposal by reference to the state of the *finite-state automaton* that corresponds to the regular expression on the right-hand side of a phrase structure rule.[3] In constructions involving nonconstituent coordination, the automaton can stop in a particular state in a phrase structure rule and can then continue from that state to analyze each conjunct of a coordinate phrase.[4] In other words, each conjunct in a coordinate structure must constitute a valid expansion of the mother category.

Maxwell and Manning note that their analysis allows a natural treatment of cases where each conjunct contains a different number of constituents. The only constituent structure requirement in an example like (34) is that each conjunct must constitute a valid completion of the VP rule, and different numbers of phrases are allowed:

(34) *You can call me [directly] or [[after three p.m.] [through my secretary]].*

---

[3] A finite-state automaton is an abstract "machine" that advances through a string, moving from state to state as the string is traversed. If the string is a member of the language of the regular expression corresponding to the automaton, the automaton is in a final state when the end of the string is reached. An automaton corresponding to the right-hand side of an LFG phrase structure rule advances through the daughter categories it encounters, moving from state to state as the daughter phrases are analyzed.

[4] As Maxwell and Manning (1996) point out, another way of thinking of the theory is in terms of the regular expression that appears on the right-hand side of a phrase structure rule; on this view, the partial phrase structure constituents that are involved in nonconstituent coordination must be members of the *suffix language* of the regular expression representing the right-hand side of a phrase structure rule, where the prefix consists of the phrase structure categories that precede the coordinated subconstituent.

As pointed out by Milward (1994), such cases are problematic for some other approaches to coordination, particularly the "3-D" approaches of Goodall (1987) and Moltmann (1992).

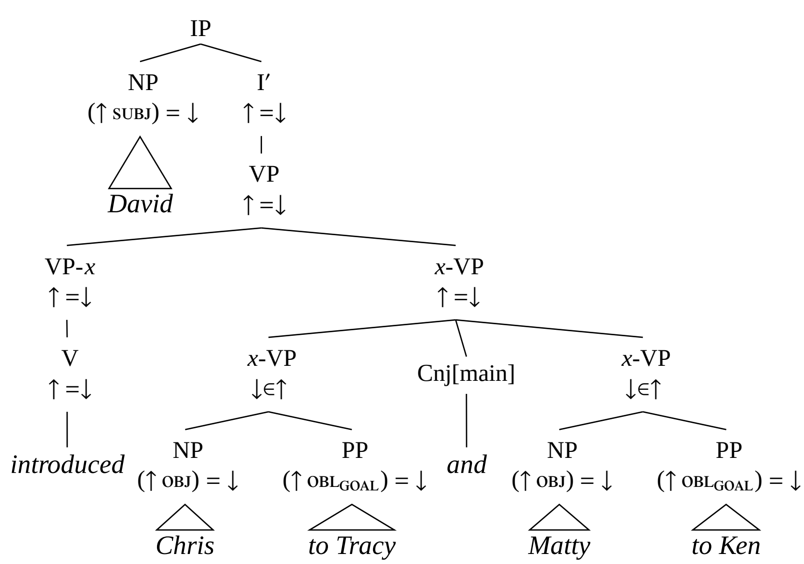
4.2. Functional Annotations

A desirable property of Maxwell and Manning's analysis is that no special stipulations are required concerning the functional structures of constructions involving nonconstituent coordination; the rules we have outlined so far give the desired result for all of the examples of nonconstituent coordination that we have discussed. We assume the standard functional annotations on phrase structure rules that we have discussed so far, and we also impose the intuitively reasonable requirement that the f-structures of the subconstituent parts of a split constituent are the same as the f-structure for the full constituent, as the annotations in the following rule indicate.

(35) $$\mathrm{VP} \longrightarrow \underset{\uparrow=\downarrow}{\mathrm{VP}\text{-}x} \quad \underset{\uparrow=\downarrow}{x\text{-}\mathrm{VP}}$$

Under these assumptions, the annotated c-structure for (25) is:

(36) *David introduced Chris to Tracy and Matty to Ken.*



These annotations give us the following f-structure, as desired:

(37) *David introduced Chris to Tracy and Matty to Ken.*

$$\left[\begin{array}{l} \text{CONJ} \quad \text{AND} \\ \left\{ \begin{array}{l} \left[\begin{array}{ll} \text{PRED} & \text{`INTRODUCE}\langle\text{SUBJ,OBJ,OBL}_{\text{GOAL}}\rangle\text{'} \\ \text{SUBJ} & \left[\text{PRED} \quad \text{`DAVID'}\right] \\ \text{OBJ} & \left[\text{PRED} \quad \text{`CHRIS'}\right] \\ \text{OBL}_{\text{GOAL}} & \left[\text{PRED} \quad \text{`TRACY'}\right] \end{array}\right] \\ \left[\begin{array}{ll} \text{PRED} & \\ \text{SUBJ} & \\ \text{OBJ} & \left[\text{PRED} \quad \text{`MATTY'}\right] \\ \text{OBL}_{\text{GOAL}} & \left[\text{PRED} \quad \text{`KEN'}\right] \end{array}\right] \end{array}\right\} \end{array}\right]$$

5. UNLIKE CATEGORY COORDINATION

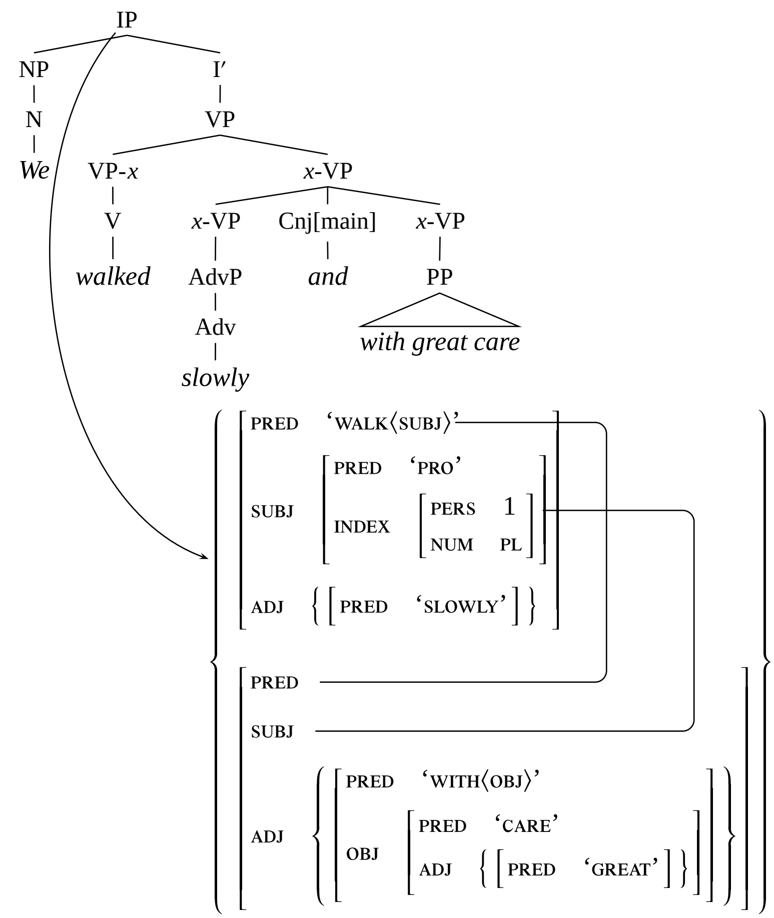
5.1. Unlike Category Coordination as Nonconstituent Coordination

Maxwell and Manning's approach to nonconstituent coordination also addresses one aspect of another long-standing problem in the syntax of coordination. Sag (2002) discusses coordination of constituents of different categories, providing examples like:

(38) *We walked [slowly]*$_{\text{AdvP}}$ *and [with great care]*$_{\text{PP}}$.

In this example, each conjunct of the coordinate phrase is an acceptable continuation of the VP in which it appears. Maxwell and Manning's treatment of nonconstituent coordination extends unproblematically to such cases:

(39) *We walked slowly and with great care.*



Notice that as an instance of nonconstituent coordination, the resulting f-structure has the status of a coordinated clausal structure, resembling the f-structure for the full clausal coordination *We walked slowly, and we walked with great care*.[5] The multiclausal analysis in (39) is suitable for examples like (38), and necessary in the analysis of examples in which the conjuncts are composed of more than one phrasal constituent, as in (25) and (34).

5.2. Unlike Category Coordination as True Coordination

Some examples of unlike category coordination cannot be analyzed in this way, however, and must be treated as standard coordination of phrases of differ-

[5] See Patejuk (2015, Chapter 5) for discussion of multiclausal versus monoclausal analyses of lexico-semantic coordination in Polish, which resembles these structures in certain respects.

ent c-structure categories. Peterson (2004a) provides the following examples of unlike category coordination, which differ crucially from the examples discussed in the previous section:

(40) a. *[A plumber] and [making a fortune] though Bill may be, he's not going to be invited to my party.* [NP and VP]

b. *[Stupid] and [a liar] Paul undoubtedly is, but he is still my friend.* [AP and NP]

c. *[In town] and [itching for a fight] is the scourge of the West, Zitty Zeke.* [PP and VP]

There are several reasons why these examples cannot be analyzed as nonconstituent coordination. First, the coordinate structures in these examples are not partial constituents which are completed by other constituents in the immediate context, and so they cannot be analyzed in terms of the rule-splitting analysis proposed by Maxwell and Manning (1996). Second, it is not possible in general for partial constituents in nonconstituent coordination to appear in contexts like those in (40):

(41) a. *David introduced [[Chris] [to Tracy]] and [[Matty] [to Ken]].*

b. **[[Chris] [to Tracy]] and [[Matty] [to Ken]] though David introduced, ...*

Examples such as those in (40) show the need for a rule which allows constituents of different categories to be coordinated to form a single coordinated constituent.

What is the c-structure category of a coordinate structure with conjuncts of different categories? Valuable clues come from predicates whose arguments must be phrases of a particular category. As discussed in Chapter 6, Section 10.3, Pollard and Sag (1994) show that the verb *wax* requires an adjectival complement, while the verb *become* requires either a nominal or an adjectival complement:

(42) a. *Fred waxed [poetical]*$_{\mathrm{AP}}$/*[lyrical]*$_{\mathrm{AP}}$.

b. **Fred waxed [a success]*$_{\mathrm{NP}}$.

c. **Fred waxed [in a good mood]*$_{\mathrm{PP}}$.

d. **Fred waxed [liking oranges]*$_{\mathrm{VP}}$.

e. **Fred waxed [quickly]*$_{\mathrm{AdvP}}$.

(43) a. *Gerry became [quite conservative]*$_{\mathrm{AP}}$.

b. *Pat has become [a Republican]*$_{\mathrm{NP}}$.

c. **Connie has become [of the opinion that we should get out]*$_{\mathrm{PP}}$.

d. **Tracy became [awarded a prize]*$_{\mathrm{VP}}$.

e. **Chris will become [talking to colleagues]*$_{\mathrm{VP}}$.

The CAT predicate, defined in (157) of Chapter 6, Section 10.3, allows for the imposition of these constraints; the XCOMP complement of *wax* must be of category AP, and the complement of *become* must be either NP or AP:

(44) a. *wax*: CAT((↑ XCOMP), {AP})

b. *become*: CAT((↑ XCOMP), {AP, NP})

Notably, unlike-category coordinated complements containing one NP complement and one AP complement are acceptable with *become*, but other unlike category coordinations are disallowed:

(45) a. *Pat has become [a Republican]*$_{\mathrm{NP}}$ *and [quite conservative]*$_{\mathrm{AP}}$.

b. **Pat has become [a Republican]*$_{\mathrm{NP}}$ *and [awarded a prize.]*$_{\mathrm{VP}}$

c. **Pat has become [quite conservative]*$_{\mathrm{AP}}$ *and [talking to colleagues.]*$_{\mathrm{VP}}$

These and other examples show that each conjunct in an unlike category coordination structure must satisfy the category requirements imposed by a predicate.

To impose the appropriate constraints in coordinate structures, Kaplan and Maxwell (1996) and Crouch et al. (2008) propose that the CAT predicate is *distributive*, and must hold of each conjunct in a coordinate structure. Under this assumption, the requirements in (44) produce the correct result for constructions involving these verbs: the complement of *wax* must be a phrase of category AP or a coordinated phrase in which all conjuncts are of category AP, while the complement of *become* must be a phrase of category NP or AP, or a coordinated phrase in which each conjunct is either NP or AP.

Treating CAT as distributive allows for checking of category requirements imposed by predicates like *wax* and *become*, but still leaves open the question of the c-structure category of an unlike category coordinate structure such as *a Republican and quite conservative* in (45a). Patejuk (2015) proposes the rule in (46), in which YP and ZP are metacategories ranging over full phrasal categories, while UP is a category label standing for Unlike Phrase for all instances of unlike category coordination.

(46) C-structure rule for unlike category coordination according to Patejuk (2015):

$$\mathrm{UP} \longrightarrow \underset{\downarrow\in\uparrow}{\mathrm{YP}} \quad \mathrm{Cnj[main]} \quad \underset{\downarrow\in\uparrow}{\mathrm{ZP}}$$

On this view, all unlike category coordinate structures have the same c-structure category: here, UP. This approach is problematic in that it complicates the grammar by requiring introduction of the category UP wherever unlike category coordination structures are allowed, in addition to standard categories such as NP or AP.

Peterson (2004a, page 652) proposes that the category of an unlike category coordinate structure is the same as the category of the first conjunct.

(47) C-structure rule for unlike category coordination according to Peterson (2004a):

$$\mathrm{X} \longrightarrow \underset{\downarrow\in\uparrow}{\mathrm{X}} \quad \mathrm{Cnj[main]} \quad \underset{\downarrow\in\uparrow}{\mathrm{Y}}$$

In this rule, X and Y are metacategories ranging over all categories; X is used as the category label of the mother node as well as the category label of the first conjunct. As noted by Patejuk (2015), this leads to the expectation that the distribution of a coordinate phrase mirrors the distribution of its first conjunct. This proposal runs into problems originally noted by Sag et al. (1985, page 141), where a coordinate structure does not have the same distribution as its first conjunct. The coordinate structure *longwinded and a bully* is acceptable as a copular complement:

(48) *The man was longwinded and a bully.*

However, this coordinate structure does not have the distribution of a normal AP, and cannot appear in other places in which AP can appear:

(49) a. *The longwinded man was my brother.*

b. **The [longwinded] and [a bully] man was my brother.*

The problem for each of these proposals is that the category of the coordinate phrase does not reflect the categories of any of the conjuncts (Patejuk 2015) or the categories of the non-initial conjuncts (Peterson 2004a). As discussed by Dalrymple (2017), this makes it difficult to enforce category-function correlations and to control the distribution of phrases of different categories. For example, if we assume a standard annotated phrase structure rule that associates the COMP grammatical function with a CP verbal complement, the Patejuk and Peterson proposals allow conjuncts of categories other than CP in an unlike category coordinate structure bearing the grammatical function COMP. We can prevent this by introducing CAT constraints throughout the grammar to control the category of the conjuncts in unlike category coordination, but the result is a considerable complication of the grammar.

Dalrymple (2017) provides an analysis of unlike category coordination which assumes that the CAT predicate is not distributive. Instead, the phrase structure category of an unlike category coordinate structure reflects properties of the categories of each of the conjuncts, and the CAT predicate constrains the category of the coordinate structure as a whole. Similar to the view of category labels advocated by Sag et al. (1985), Marcotte (2014), and Bresnan et al. (2016), this proposal assumes that category labels are feature structures with features encoding phrasal category as well as bar level, the status of the category as functional or lexical, and whether the category is a projecting or a nonprojecting category. The category label in a coordinate structure is determined on the basis of the category features of each of the conjuncts: for example, a noun phrase bears the feature N with value +; an adjective phrase bears the feature ADJ with value +; and a coordinate structure containing a noun phrase conjunct and an adjective phrase conjunct bears both features, N + and ADJ +. Predicates such as *wax* and *become* place requirements on the feature composition of their complement by use of the CAT predicate: *wax* requires an adjectival complement, with value − for all features except for the feature ADJ, and *become* requires an adjectival or nominal complement, with value − for all features except for the features ADJ and N. See Dalrymple (2017) for further discussion and exemplification.

As observed by Bayer (1996), the successful treatment of category features in unlike category coordination is very much dependent on the feature inventory that is assumed: Bayer discusses difficulties in the analysis of predicates which require either an NP or S complement under Sag et al.'s assumptions, where NP has the features [+N, −V], and S has the features [−N, +V], with no features in common. In fact, the same issues in the definition and representation of f-structure features discussed in Chapter 2, Section 5.1 arise for c-structure category features. For example, Bresnan et al. (2016, Chapter 6) propose a two-dimensional classification of c-structure features as 'predicative' (verbs and adjectives) and 'non-predicative' (prepositions and nouns), and as 'transitive' (verbs and prepositions) and 'non-transitive' (nouns and adjectives). These features successfully capture the phrase-internal properties of these categories: verbs and prepositions can take objects, but nouns and adjectives generally do not, for example. However, they do not straightforwardly allow for the statement of selection requirements when these phrases are selected by predicates.

6. COORDINATION PATTERNS CROSSLINGUISTICALLY

We now propose a set of coordination macros, allowing us to incorporate the patterns and constraints discussed in the preceding sections of this chapter. Haspelmath (2004) points out that there are four types of coordination patterns attested crosslinguistically, depending on the number of conjunctions in the coordinate structure.[6]

(50) a. Asyndetic coordination (no conjunction): *X Y Z*

[mox c'iiza b-yylira]; [darc hwovziira].
wind howl.INF B-start.WP blizzard turn.around.WP

'The wind started to howl, and the blizzard turned around.' (Chechen: Jeschull 2004, page 252)

b. One conjunction in the coordinate structure: *X Y and Z*
[David got up], [Chris sat down], and [Matty left the room].

c. One fewer conjunction than the number of conjuncts: *X and Y and Z*
[David got up] and [Chris sat down] and [Matty left the room].

d. One conjunction for each conjunct: *X and Y and Z and*

[6]The terminology used by Haspelmath (2004) for these four types is somewhat confusing: he uses the term *monosyndetic coordination* for what we call 'one fewer conjunction than the number of conjuncts', treating the one-conjunction type as monosyndetic coordination with ellipsis of all but one conjunction, and he uses the term *bisyndetic coordination* for what we call 'one conjunction for each conjunct'.

hun eer d-u caara, [shain k'ant-a moliila]
what say.FUT D-be.PRS they.ERG themselves.GEN boy-ERG drink.SUBJ
'a, [i lovzush v-yyla] 'a xi'cha.
and he play.SCV V-be.SUBJ and find.out.when

'What will they say if they find out that their son drinks and he plays?'
(Chechen: Jeschull 2004, page 254)[7]

In (51a) we define a rule macro[8] CNJ(_c) for a sequence consisting of a conjunction such as *and* or *or* and a conjunct of category _c. This macro is useful for English, where the conjunction precedes the conjunct; in a language where the conjunction follows the conjunct, as in the Chechen example in (50d), an alternative macro encoding the other order would be required. The basic macro in (51a) allows us to define additional general macros for each of these construction types, as shown in (51b-e), using the Kleene plus operator to require one or more occurrences of a phrase. These macros will also be useful in our discussion of the semantics of coordinate phrases in Section 8.3.

(51) a. Definition of the rule macro CNJ(_c):

$$\text{CNJ}(\_c) \equiv \underset{\uparrow = \downarrow}{\text{Cnj[main]}} \quad \underset{\downarrow \in \uparrow}{\_c}$$

b. Asyndetic coordination:

$$\text{ASYNDETIC-COORD}(\_c) \equiv \underset{\downarrow \in \uparrow}{\_c^{+}}$$

c. One conjunction in the coordinate structure:

$$\text{ONE-CONJ}(\_c) \equiv \underset{\downarrow \in \uparrow}{\_c^{+}} \quad @\text{CNJ}(\_c)$$

d. One fewer conjunction than the number of conjuncts:

$$\text{ONE-FEWER-CONJ}(\_c) \equiv \underset{\downarrow \in \uparrow}{\_c} \quad @\text{CNJ}(\_c)^{+}$$

e. One conjunction for each conjunct:

$$\text{ONE-EACH-CONJ}(\_c) \equiv @\text{CNJ}(\_c)^{+}$$

For English, the structures represented by the rule macros ONE-CONJ and ONE-FEWER-CONJ are both used; we thus provide a single macro ENGLISH-COORD which allows either the 'one conjunction in the coordinate structure' pattern or the 'one fewer conjunction than the number of conjuncts' pattern, which we will build on in our discussion of the semantics of coordination. This macro requires a coordinate structure to consist of an optional preconjunction,[9] an initial conjunct,

[7] Placement of the conjunction *'a* in Chechen is governed by complex rules; see Jeschull (2004) for a full discussion.

[8] See Chapter 6, Section 8 for definition and discussion of rule macros.

[9] The preconjunction *both* requires the coordinate phrase to have only two conjuncts; in light of noncoordinate examples involving the related determiner *both* in examples like *both (the) girls*, which

any number of medial conjuncts, and a final conjunction and conjunct phrase. The medial conjuncts must either all have conjunctions (as defined by the rule macro @CNJ(_c) or all lack conjunctions (the simple category _c).

(52) Rule macro for English coordination:

$$\textsc{english-coord}(\_c) \equiv$$

$$\begin{pmatrix}\text{Cnj[pre]}\\ \uparrow=\downarrow\end{pmatrix} \quad \begin{matrix}\_c\\ \downarrow\in\uparrow\end{matrix} \quad \left\{ \begin{matrix}\_c^{*}\\ \downarrow\in\uparrow\end{matrix} \;\middle|\; @\textsc{cnj}(\_c)^{*} \right\} \quad @\textsc{cnj}(\_c)$$

This macro allows the statement of coordination rules for a range of c-structure categories as in (52), exemplifying with V and IP.

(53) Coordination rules using the rule macro in (52):

$$\text{V} \longrightarrow @\textsc{english-coord}(\text{V})$$

$$\text{IP} \longrightarrow @\textsc{english-coord}(\text{IP})$$

Constraints lexically associated with the preconjunctions *both* and *either* prevent their appearance with certain phrase structure categories. For instance, as shown in (19), *both* cannot appear with coordinated nouns (**The both [sandwich] and [soup] are cold*), though it can appear with coordinated noun phrases (*Both [the man] and [the woman] sneezed*); this constraint is reflected in the final line of this lexical entry for *both*, which disallows coordinate structures with category N:

(54) *both* Cnj[pre] $(\uparrow \textsc{preconj}) = \textsc{both}$
$(\uparrow \textsc{conj}) =_c \textsc{and}$
$\text{N} \notin \phi^{-1}(\uparrow)$

The rule macro in (52) is sufficient to account for the syntactic patterns which we have examined so far. We will augment this rule macro in two ways in the remainder of this chapter. First, in our discussion of the compositional semantics of coordination, we designate one of the conjuncts as the 'seed' and treat it specially in semantic composition; this requires a separate macro encoding the special semantic role of the 'seed' conjunct. Second, in our discussion of feature resolution patterns in nominal coordination, we propose additional constraints to ensure that the appropriate resolved features are assigned to a nominal coordinate structure.

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refers to two girls, we take this to be a semantic fact, and we do not encode this constraint in the c-structure rule. Prescriptively, the preconjunction *either* is sometimes also claimed to require only two conjuncts, but examples with three or more conjuncts are commonly found: *I'll either [call out] or [bang on the door] or [blow my whistle]* (Huddleston and Pullum 2002, 2005).

7. COORDINATION AND SEMANTIC COMPOSITION

7.1. Clausal Coordination

The meaning of a coordinated sentence like *Chris yawned and David sneezed* is usually represented simply as the conjunction of the meanings of the conjuncts:[10]

(55) *Chris yawned and David sneezed.*

$$\mathit{yawn}(\mathit{Chris}) \wedge \mathit{sneeze}(\mathit{David})$$

For the sentence *Chris yawned and David sneezed* to be true, it must be the case both that Chris yawned and that David sneezed. We assume the following f-structure and meaning constructor for this example:

(56) *Chris yawned and David sneezed.*

$$a\left[\begin{array}{l} \textsc{conj} \quad \textsc{and} \\ \left\{\begin{array}{l} y\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{yawn}\langle\textsc{subj}\rangle\text{'} \\ \textsc{subj} & c\left[\begin{array}{ll}\textsc{pred} & \text{`Chris'}\end{array}\right] \end{array}\right] \\ \\ s\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{sneeze}\langle\textsc{subj}\rangle\text{'} \\ \textsc{subj} & d\left[\begin{array}{ll}\textsc{pred} & \text{`David'}\end{array}\right] \end{array}\right] \end{array}\right\} \end{array}\right]$$

$$\mathit{yawn}(\mathit{Chris}) \wedge \mathit{sneeze}(\mathit{David}) : a_\sigma$$

To obtain this result, we adopt the compositional analysis of Asudeh and Crouch (2002a),[11] which can be intuitively described as follows. One of the conjuncts in a coordinate structure is the 'seed', or the initial resource contributed to the meaning of a coordinate structure. A special meaning constructor assigns the meaning of this conjunct to be the initial meaning of the coordinate structure as a whole. The other conjuncts are associated with meaning constructors which add their meanings to the 'seed' one by one, with the result that the meanings of all of the conjuncts are combined to produce the final, complete and coherent meaning of the coordinate structure.

We begin our discussion by inspecting the meaning constructor in (57), which is associated with the seed conjunct in the phrase structure rule for clausal coordination. Its effect is to consume the resource associated with the seed conjunct daughter ($\downarrow_\sigma$, of type t) and reassociate its meaning with the coordinate structure as a whole ($\uparrow_\sigma$, also of type t). Note that this meaning constructor is specified

[10] Since we are not concerned with anaphoric relations in this chapter, we do not need the expressive power of PCDRT, and we use predicate logic as our meaning language.

[11] Dalrymple (2001) follows Kehler et al. (1995) in proposing an analysis that uses the *of course* operator of linear logic, written as an exclamation point, to turn off resource accounting in the analysis of coordinate structures. Asudeh and Crouch (2002a) observe that this analysis goes against the spirit of the glue approach, which has a strong commitment to the preservation of resource sensitivity in meaning composition, and so we do not adopt that analysis here.

as applying only to conjuncts of type *t*; we extend this treatment to coordination of conjoinable types (types 'ending in *t*') in Section 7.2, and we discuss nominal coordination and group formation in Section 8.2. We temporarily ignore the treatment of the meaning resource of the conjunction, but we return to this issue immediately below.

(57) Preliminary meaning constructor for seed conjunct, to be revised

$\lambda P.P : \downarrow_{\sigma\langle t\rangle} \multimap \uparrow_{\sigma\langle t\rangle}$

We also require a specification of the meaning of the conjunction. Following Asudeh and Crouch (2002a), we assume that the meaning of the conjunction is associated with the COORD-REL attribute at semantic structure ($\wedge$ for *and*, $\vee$ for *or*).[12] The type of this meaning is $\langle t \rightarrow \langle t \rightarrow t\rangle\rangle$; to save space, we do not explicitly represent this in the meaning constructors which we present.

(58) Lexical entries for *and* and *or*, including meaning constructors

and	Cnj[main]	$(\uparrow \text{CONJ}) = \text{AND}$ $\wedge : (\uparrow_\sigma \text{COORD-REL})$
or	Cnj[main]	$(\uparrow \text{CONJ}) = \text{OR}$ $\vee : (\uparrow_\sigma \text{COORD-REL})$

We also require meaning constructors which have the effect of adding the meaning of the non-seed conjuncts to the meaning of the seed to produce the meaning for the full coordinate structure.[13] The meaning constructor for each

[12] This raises a resource issue. In Section 6, we noted the 'one conjunction for each conjunct' pattern of coordination, where multiple conjunctions can appear in a single coordinate structure. If each conjunction contributes a meaning constructor to the same coordinate structure, but only one meaning constructor is needed for interpretation of the coordinate structure, resource surplus results. We can address this issue by providing a more complex lexical entry such as (a), which uses an *instantiated symbol* (Chapter 5, Section 2.2.1) as the value for the CONJ feature; recall that an instantiated symbol is like a semantic form in that it takes on a unique value for each instance of use. The lexical entry in (a) contains a disjunction: in the first case, the CONJ feature is contributed with an instantiated (unique) value, and the meaning constructor is also contributed; in the second case, a constraining equation checks that another instance of the conjunction has contributed a unique value for the CONJ feature. This ensures that only one instance of the conjunction contributes a meaning constructor.

(a) *and* Cnj[main] $\{ \; (\uparrow \text{CONJ}) = \text{AND\_} \;\; \wedge : (\uparrow_\sigma \text{COORD-REL}) \; \mid \; (\uparrow \text{CONJ}) =_c \text{AND\_} \; \}$

In the following discussion, for simplicity, we do not discuss the 'one conjunction for each conjunct' pattern, and we use the less complicated lexical entry in (58).

[13] Winter (2006) provides an illuminating discussion of the complex issues raised by the distinction between binary coordination (as assumed here and by Asudeh and Crouch 2002a), where a coordinate structure with three conjuncts A, B, C is given a binary analysis $\mathit{and}(A, \mathit{and}(B, C))$, as opposed to a 'flat' treatment like $\mathit{and}(\{A, B, C\})$. Winter provides evidence indicating that the binary analysis is superior, though it may be that some of the advantages he adduces for binary structure are better explained by assuming syntactic ambiguity rather than ambiguity of semantic composition. There is no obstacle to the formulation of a 'flat' treatment of coordination in a glue setting, though we do not

non-seed conjunct consumes the meaning resource of the conjunct (associated with $\downarrow_\sigma$, which is of type *t*) and combines the meaning of the conjunct with the meaning of the coordinate structure derived so far (associated with $\uparrow_\sigma$), using the meaning of the conjunction (associated with ($\uparrow_\sigma$ COORD-REL)) to combine them.[14] This means that we must also manage the meaning resource contributed by the conjunction, which may need to be reused several times in a coordinate structure with more than two conjuncts: for this reason, the COORD-REL resource is both consumed and produced by this meaning constructor, so that it can be consumed and produced again by another conjunct.

(59) Meaning constructor for non-seed clausal conjuncts:

$$\textbf{[conj0]} \quad \lambda P.\lambda Q.\lambda C.C(P, Q(C)):$$
$$\downarrow_{\sigma\langle t\rangle} \multimap [(\uparrow_\sigma \text{ COORD-REL}) \multimap \uparrow_{\sigma\langle t\rangle}] \multimap [(\uparrow_\sigma \text{ COORD-REL}) \multimap \uparrow_{\sigma\langle t\rangle}]$$

To produce a complete and coherent meaning for the sentence, the meaning constructor in (58) for the conjunction must be consumed in the course of the derivation, like other meaning resources. According to Asudeh and Crouch (2002a), this is accomplished by the meaning constructor for the seed conjunct, which appears in its final form in (60). In fact, the meaning of the seed conjunct consumes the resource ($\uparrow_\sigma$ COORD-REL) contributed by the conjunction, but does not incorporate the meaning *C* of the conjunction; the resulting meaning reflects only the meaning *P* of the seed conjunct.

(60) Meaning constructor for seed clausal conjunct:

$$\textbf{[seed0]} \quad \lambda P.\lambda C.P : \downarrow_{\sigma\langle t\rangle} \multimap [(\uparrow_\sigma \text{ COORD-REL}) \multimap \uparrow_{\sigma\langle t\rangle}]$$

We now associate the **[seed0]** and **[conj0]** meaning constructors with the phrase structure rule for coordination, exemplifying with a modified version of the rule macro for English coordination given in (52). Following Asudeh and Crouch (2002a), we treat the final conjunct as the seed, though nothing rests on this choice; the first conjunct or any other conjunct could be chosen instead. Given this choice, the final conjunct is associated with a different meaning constructor from the nonfinal conjuncts, and so we define a new macro FINAL-CONJ for the final conjunct, associated with the **[seed0]** meaning constructor; the non-final conjuncts are associated with the **[conj0]** meaning constructor.

(61) a. Definition of the rule macro CNJ(_c):

$$\text{CNJ(\_c)} \equiv \begin{array}{cc} \text{Cnj[main]} & \text{\_c} \\ \uparrow = \downarrow & \downarrow \in \uparrow \\ & \textbf{[conj0]} \end{array}$$

provide the details here; indeed, a 'flat' treatment would be simpler in some respects, in that it would not require multiple copies of the conjunction in assembling the meaning of the coordinate structure.

[14] The meaning constructor in (59) produces the meaning $\wedge(\textit{yawn}(\textit{Chris}),\textit{sneeze}(\textit{David}))$ for example (1), with $\wedge$ as a predicate taking the meanings of the two conjuncts as its arguments. This is a notational variant of the expression $\textit{yawn}(\textit{Chris}) \wedge \textit{sneeze}(\textit{David})$, and we will use the two variants interchangeably.

b. Definition of the rule macro $\textsc{final-cnj}(\_c)$:

$$\textsc{final-cnj}(\_c) \;\equiv\; \begin{array}{c}\text{Cnj[main]}\\ \uparrow=\downarrow\end{array} \qquad \begin{array}{c}\_c\\ \downarrow\in\uparrow\\ \textbf{[seed0]}\end{array}$$

c. Revised rule macro for English clausal coordination:

$$\textsc{english-coord}(\_c) \;\equiv$$

$$\left(\begin{array}{c}\text{Cnj[pre]}\\ \uparrow=\downarrow\end{array}\right) \quad \begin{array}{c}\_c\\ \downarrow\in\uparrow\\ \textbf{[conj0]}\end{array} \quad \left\{\begin{array}{c}\_c^{*}\\ \downarrow\in\uparrow\\ \textbf{[conj0]}\end{array} \;\middle|\; @\textsc{cnj}(\_c)^{*}\right\} \quad @\textsc{final-cnj}$$

We now go through the glue deduction for the clausal coordination *Chris yawned and David sneezed*.

(62) *Chris yawned and David sneezed.*

$$a\left[\begin{array}{ll}\textsc{conj} & \textsc{and}\\ & \left\{\begin{array}{l} y\left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{yawn}\langle\textsc{subj}\rangle\text{’}\\ \textsc{subj} & \left[\textsc{pred}\;\; \text{‘}\textsc{Chris}\text{’}\right]\end{array}\right]\\ \\ s\left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{sneeze}\langle\textsc{subj}\rangle\text{’}\\ \textsc{subj} & \left[\textsc{pred}\;\; \text{‘}\textsc{David}\text{’}\right]\end{array}\right]\end{array}\right\}\end{array}\right] \xrightarrow{\sigma} a_\sigma\left[\textsc{coord-rel}\;\; c[\;]\right]$$

$$\mathit{yawn}(\mathit{Chris}) \wedge \mathit{sneeze}(\mathit{David}) : a_\sigma$$

(63) $\textsf{yawn}(\textsf{Chris}) : y_\sigma$

This is the meaning constructor **[Chris-yawn]**. It associates the meaning $\textsf{yawn}(\textsf{Chris})$ with the semantic structure y_σ.

$\lambda P.\lambda Q.\lambda C.C(P, Q(C)) : y_\sigma \multimap [[c \multimap a_\sigma] \multimap [c \multimap a_\sigma]]$

This is the meaning constructor **[conj0]** associated with the first conjunct of the phrase structure rule for clausal coordination.

$\lambda Q.\lambda C.C(\textsf{yawn}(\textsf{Chris}), Q(C)) : [[c \multimap a_\sigma] \multimap [c \multimap a_\sigma]]$

Combining **[conj0]** with **[Chris-yawn]**, we have this meaning constructor, which we call **[Chris-yawn-conj]**.

$\textsf{sneeze}(\textsf{David}) : s_\sigma$

This is the meaning constructor **[David-sneeze]**. It associates the meaning $\textsf{sneeze}(\textsf{David})$ with the semantic structure s_σ.

$\lambda P.\lambda C.P : s_\sigma \multimap [c \multimap a_\sigma]$

This is the meaning constructor **[seed0]** associated with the final conjunct of the phrase structure rule for clausal coordination.

$\lambda C.\textsf{sneeze}(\textsf{David}) : [c \multimap a_\sigma]$

Combining **[seed0]** with **[David-sneeze]**, we have this meaning constructor, which we call **[David-sneeze-seed]**. Notice that this meaning involves vacuous abstraction over the meaning of the conjunction C.

$\lambda C.C(\textsf{yawn}(\textsf{Chris}), \textsf{sneeze}(\textsf{David})) : [c \multimap a_\sigma]$

On the glue side, **[David-sneeze-seed]** is associated with the resource $[c \multimap a_\sigma]$, which is of exactly the form required by **[Chris-yawn-conj]**. Combining **[David-sneeze-seed]** and **[Chris-yawn-conj]**, we obtain this meaning constructor, which requires a resource for the conjunction C.

$\wedge : c$

This is the meaning constructor **[and]**. It provides the meaning $\wedge$ contributed by the conjunction *and*.

$\textsf{yawn}(\textsf{Chris}) \wedge \textsf{sneeze}(\textsf{David}) : a_\sigma$

Combining the meaning constructors in the previous two steps, we have the meaning constructor for *Chris yawned and David sneezed*, as desired.

7.2. Subsentential Coordination

As with clausal coordination, coordination of subsentential units involves conjunction of the meanings of the conjunct phrases. The f-structure and meaning constructor for the sentence *Tracy sang and danced* are:

(64) *Tracy sang and danced.*

$$a\left[\begin{array}{ll} \textsc{conj} & \textsc{and} \\ \multicolumn{2}{l}{\left\{\begin{array}{l} s\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{sing}\langle\textsc{subj}\rangle\text{'} \\ \textsc{subj} & t\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{Tracy}\text{'}\end{array}\right] \end{array}\right] \\ \\ d\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{dance}\langle\textsc{subj}\rangle\text{'} \\ \textsc{subj} & \rule{4cm}{0.4pt} \end{array}\right] \end{array}\right\}} \end{array}\right]$$

$sing(Tracy) \wedge dance(Tracy) : a_\sigma$

In this example, the subject *Tracy* of the conjoined verbs *sang* and *danced* is shared across the conjuncts in the coordinate structure, as described in Section 2. Argument sharing in subsentential coordination presents a special challenge for a resource-based account of the syntax-semantics interface.

In (64), the subject *Tracy* is shared by the verbs *sang* and *danced*, and each verb requires a meaning contribution from its subject. Our theory of meaning assembly and the syntax-semantics interface relies crucially on the assumption that the meaning constructor for *Tracy* makes a single, unique meaning contribution. Clearly, however, the acceptability of (64) entails that this single meaning contribution can satisfy the requirements imposed by each of the verbs in the coordinate structure *sang and danced*. Therefore, in the analysis of examples like (64), we require a theory of resource management in argument sharing that accounts for the grammaticality of examples like *Tracy sang and danced* while maintaining the desirable properties of our linear-logic-based glue approach.

In fact, reliance on a theory of resource management in the analysis of examples like (64) is of paramount importance: the acceptability of (64) does *not* indicate that resource accounting is completely abandoned for the shared argument *Tracy*. If resource accounting were switched off entirely for shared dependents — for example, by prefixing the meaning constructor for *Tracy* with the linear logic *of course* operator, allowing it to be used any number of times — we would have no way of accounting for the unacceptability of examples like:

(65) **Chris selected and arrived Tracy.*

This example is syntactically and semantically incoherent. Syntactic requirements on verb coordination, discussed in Section 2, entail that *Tracy* must appear as the OBJ argument of the verbs *selected* and *arrived*. However, the intransitive verb *arrived* does not require an OBJ resource, and so if an OBJ resource is provided, it is not consumed in the meaning derivation and remains unused at the end of the deduction, leading to semantic incoherence. If resource accounting were switched off for *Tracy*, it could contribute one semantic resource to this sentence, and not the expected two. This would satisfy the requirements of the verb *selected*, violate no semantic requirements imposed by the verb *arrived*, and incorrectly result in a semantically coherent deduction. This example shows that resource accounting must in fact be enforced for (65), as it is in all other cases. We require, then, a complete and explicit theory of resource accounting, argument sharing, and their interactions.

Particular care must be taken in the treatment of certain kinds of arguments shared across conjunctions. As noted by Partee (1970), a sentence like *Someone sang and danced* has the following meaning:

(66) *Someone sang and danced.*

$\mathit{a}(x, \mathit{person}(x), \mathit{sing}(x) \wedge \mathit{dance}(x))$

Here, the single quantifier *someone* scopes over the coordinate structure, and the variable x bound by the quantifier appears as an argument of both *sing* and *dance*. This meaning is not the same as the one for the sentence *Someone sang and someone danced*:

(67) *Someone sang and someone danced.*

$\mathit{a}(x, \mathit{person}(x), \mathit{sing}(x)) \wedge \mathit{a}(y, \mathit{person}(y), \mathit{dance}(y))$

In (67), different people might be involved in each activity, while (66) requires that there is a single person who both sang and danced. This fact must also be captured by our theory of argument sharing and semantic composition.

Kehler et al. (1995) were the first to propose a treatment of argument sharing and resource management within the glue approach, and a similar approach was adopted by Dalrymple (2001). That proposal appeals to the geometry of f-structures in constructions involving argument sharing: intuitively, their approach focuses on *occurrences* of f-structures, where an f-structure occurs more than once if there is more than one path leading to it. Semantic resources are associated with *paths* through the f-structure and thus with occurrences of f-structures; in essence, Kehler et al. (1995) provide a means for making one copy of a semantic resource for each f-structure path leading to its corresponding f-structure.

For instance, in the analysis of (64), there are two paths leading to the f-structure for *Tracy*, since the f-structure for *Tracy* appears as the value of two different SUBJ attributes. On Kehler et al.'s analysis, each verb requires a semantic resource associated with the path leading to its SUBJ. Since the f-structure for *Tracy* appears at the end of each of these two paths, two copies of the meaning constructor for *Tracy* are made available, and a semantically complete and coherent meaning deduction results.

This approach successfully accounts for the acceptability of examples involving argument sharing by allowing the creation of as many semantic resources as are needed to satisfy the requirements of each predicate involved in the sharing of a single argument. However, a major problem with this approach is that it also allows resource duplication in cases where such duplication is unwarranted.

For example, constructions with raising verbs also exhibit argument sharing: the subject of a verb like *seem* is also the subject of its XCOMP (Chapter 15, Section 1). As pointed out by Asudeh (2000), we do not wish to enforce resource duplication in this case; as discussed in Chapter 15, Section 2.2, the derivation of the meaning *seem*(*yawn*(*David*)) of a sentence like *David seemed to yawn* requires exactly one occurrence of the meaning resource contributed by *David*, not two. Similarly, resource duplication is not warranted in constructions in which an f-structure is involved in a long-distance dependency and appears as a member of the DIS set as well as bearing an argument function. In these cases, relying simply on the geometry of the f-structure to license feature duplication leads to the wrong result; a more constrained theory is needed.

Instead, we adopt a variant of the approach to resource management proposed by Asudeh and Crouch (2002a). This approach provides special rules to combine the semantic requirements imposed by each predicate that shares an argument into a requirement for a single semantic resource.

In order to introduce the approach, we propose special-purpose templates **[conj1]** and **[seed1]** for coordinated predicates which share one argument, as in (68); these templates are special cases of the general approach to be presented later in this section. These resemble the **[seed0]** and **[conj0]** templates in (59) and (60), except that the meaning constructors for the conjoined phrases each require a SUBJ argument, and the coordinate structure as a whole requires a SUBJ argument which is shared across the conjunct daughters. The underlined portion of the glue side of the meaning constructors in (68) is different from the meaning constructors in (59) and (60) in that the resources involved are implicational, requiring a SUBJ; other aspects of their structure are the same. Thus, the meaning constructor in (68a) combines two conjuncts which are each missing a subject, and produces a resource for the coordinate structure which is still missing a subject. A single resource satisfies the missing-subject requirement of the coordinate structure.

(68) a. Meaning constructor for non-seed conjuncts sharing SUBJ, provisional:

[conj1] $\lambda P.\lambda Q.\lambda C.\lambda x.C(P(x), Q(C, x))$:

$$\underline{[(\downarrow \mathrm{SUBJ})_\sigma \multimap \downarrow_{\sigma\langle t\rangle}]} \multimap [(\uparrow_\sigma \mathrm{COORD\text{-}REL}) \multimap \underline{[(\uparrow \mathrm{SUBJ})_\sigma \multimap \uparrow_{\sigma\langle t\rangle}]}] \multimap [(\uparrow_\sigma \mathrm{COORD\text{-}REL}) \multimap \underline{[(\uparrow \mathrm{SUBJ})_\sigma \multimap \uparrow_{\sigma\langle t\rangle}]}]$$

b. Meaning constructor for seed conjunct sharing SUBJ, provisional:

[seed1] $\lambda P.\lambda C.\lambda x.P(x) : \underline{[(\downarrow \mathrm{SUBJ})_\sigma \multimap \downarrow_{\sigma\langle t\rangle}]} \multimap [(\uparrow_\sigma \mathrm{COORD\text{-}REL}) \multimap \underline{[(\uparrow \mathrm{SUBJ})_\sigma \multimap \uparrow_{\sigma\langle t\rangle}]}]$

We now associate the components of the English coordination rule macro with these templates. Below, we will provide a general definition that covers coordination at various clause levels.

(69) a. Alternative definition of the rule macro CNJ(_c), provisional:

$$\begin{array}{lccc} \mathrm{CNJ}(\_c) & \equiv & \mathrm{Cnj[main]} & \_c \\ & & \uparrow = \downarrow & \downarrow \in \uparrow \\ & & & \textbf{[conj1]} \end{array}$$

b. Alternative definition of the rule macro FINAL-CNJ(_c), provisional:

$$\textsc{final-cnj}(\_c) \equiv \quad \begin{array}{c} \text{Cnj[main]} \\ \uparrow = \downarrow \end{array} \quad \begin{array}{c} \_c \\ \downarrow \in \uparrow \\ \textbf{[seed1]} \end{array}$$

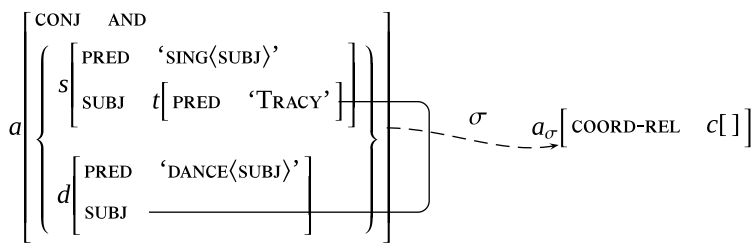
c. Alternative rule macro for English coordination, provisional:

$$\textsc{english-coord}(\_c) \equiv$$

$$\left(\begin{array}{c} \text{Cnj[pre]} \\ \uparrow = \downarrow \end{array} \right) \quad \begin{array}{c} \_c \\ \downarrow \in \uparrow \\ \textbf{[conj1]} \end{array} \quad \left\{ \begin{array}{c} \_c^{*} \\ \downarrow \in \uparrow \\ \textbf{[conj1]} \end{array} \middle| \; @\textsc{cnj}(\_c)^{*} \right\} \quad @\textsc{final-cnj}$$

Using these modified templates and this rule, we can derive the desired meaning for *Tracy sang and danced*, where the requirement for each verb to combine with a SUBJ is satisfied by a single resource associated with the subject *Tracy*.

(70) *Tracy sang and danced.*



$sing(Tracy) \wedge dance(Tracy) : a_\sigma$

(71) $\lambda x.\mathit{sing}(x) : t_\sigma \multimap s_\sigma$

This is the meaning constructor **[sing]**. It associates the meaning $\lambda x.\mathit{sing}(x)$ with the implicational resource $t_\sigma \multimap s_\sigma$, which requires a subject resource t_σ.

$\lambda P.\lambda Q.\lambda C.\lambda x.C(P(x), Q(C, x)) : [t_\sigma \multimap s_\sigma] \multimap [[c \multimap [t_\sigma \multimap a_\sigma]] \multimap [c \multimap [t_\sigma \multimap a_\sigma]]]$

This is the meaning constructor **[conj1]** associated with the first conjunct of the phrase structure rule for clausal coordination.

$\lambda Q.\lambda C.\lambda x.C(\mathit{sing}(x), Q(C, x)) : [[c \multimap [t_\sigma \multimap a_\sigma]] \multimap [c \multimap [t_\sigma \multimap a_\sigma]]]$

Combining **[conj1]** with **[sing]**, we have this meaning constructor, which we call **[sing-conj]**.

$\lambda x.\mathit{dance}(x) : t_\sigma \multimap d_\sigma$

This is the meaning constructor **[dance]**. It associates the meaning $\lambda x.\mathit{dance}(x)$ with the implicational resource $t_\sigma \multimap d_\sigma$.

$\lambda P.\lambda C.\lambda x.P(x) : [t_\sigma \multimap d_\sigma] \multimap [c \multimap [t_\sigma \multimap a_\sigma]]$

This is the meaning constructor **[seed1]** associated with the final conjunct of the phrase structure rule for clausal coordination.

$\lambda C.\lambda x.\mathit{dance}(x) : [c \multimap [t_\sigma \multimap a_\sigma]]$

Combining **[seed1]** with **[dance]**, we have this meaning constructor, which we call **[dance-seed]**. Notice that this meaning involves vacuous abstraction over the meaning of the conjunction C.

$\lambda C.\lambda x.C(\mathit{sing}(x), \mathit{dance}(x)) : [c \multimap [t_\sigma \multimap a_\sigma]]$

On the glue side, **[dance-seed]** is associated with the resource $[c \multimap [t_\sigma \multimap a_\sigma]]$, which is of exactly the form required by **[sing-conj]**. Combining **[dance-seed]** and **[sing-conj]**, we obtain this meaning constructor, which we call **[sing-dance]**; it requires a meaning C for the conjunction c and a meaning x for the subject.

$\wedge : c$	This is the meaning constructor **[and]**. It provides the meaning $\wedge$ contributed by the conjunction *and*.
$\lambda x.\mathit{sing}(x) \wedge \mathit{dance}(x) : t_\sigma \multimap a_\sigma$	Combining **[sing-dance]** with **[and]**, we have the meaning constructor corresponding to the conjunction *sang and danced*, which requires a single resource t_σ for the subject.
$\mathit{Tracy} : t_\sigma$	This is the SUBJ meaning constructor **[Tracy]**.
$\mathit{sing}(\mathit{Tracy}) \wedge \mathit{dance}(\mathit{Tracy}) : a_\sigma$	Combining the meaning constructors in the previous two steps, we have the meaning constructor for *Tracy sang and danced*, as desired.

This derivation shows that it is possible to provide meaning constructors of very similar shape — **[seed0]** and **[seed1]**, **[coord0]** and **[coord1]** — for conjunction of what Partee and Rooth (1983) call *conjoinable types*, sometimes called 'types ending in *t*': meanings of type t, $\langle e \rightarrow t\rangle$, $\langle e \rightarrow \langle e \rightarrow t\rangle\rangle$, and so on.

(72) Definition of Conjoinable Type (Partee and Rooth 1983, page 363):

a. t is a conjoinable type

b. if b is a conjoinable type, then for all a, $\langle a, b\rangle$ is a conjoinable type.

What is needed, then, is a single rule schema which can be used for coordination of conjuncts of any conjoinable type: clausal coordination with conjuncts of type t producing a coordinate structure of type t, predicate coordination with conjuncts of type $\langle e \rightarrow t\rangle$ producing a coordinate predicate of type $\langle e \rightarrow t\rangle$, and so on. As Asudeh and Crouch (2002a) point out, similar proposals have been made in many theoretical settings (Gazdar 1980; Keenan and Faltz 1985; Emms 1990), though the approach is most commonly associated with Categorial Grammar treatments of coordination (Steedman 1985, 2001; Morrill 2011): Steedman (2001, page 39) refers to the "ancient intuition that coordination is an operation that maps two constituents of like type onto a constituent of the same type". Building on observations by Asudeh and Crouch (2002a), we propose the following schematic definitions of **[conj]** and **[seed]**, which differ from **[conj0]**/**[conj1]** and **[seed0]**/**[seed1]** in the underlined portion; these template schemas allow coordinate structures of all conjoinable types (resources of type t and any resources that depend on them).

(73) a. Meaning constructor for non-seed conjuncts, final:

[conj] $\lambda P.\lambda Q.\lambda C.\lambda \vec{x}.C(P(\vec{x}), Q(C, \vec{x}))$:

$\underline{[\langle\vec{\alpha}\rangle_n \multimap \downarrow_{\sigma\langle t\rangle}]} \multimap [(\uparrow_\sigma \text{COORD-REL}) \multimap \underline{[\langle\vec{\alpha}\rangle_n \multimap \uparrow_{\sigma\langle t\rangle}]}] \multimap [(\uparrow_\sigma \text{COORD-REL}) \multimap \underline{[\langle\vec{\alpha}\rangle_n \multimap \uparrow_{\sigma\langle t\rangle}]}]$

b. Meaning constructor for seed conjunct, final:

$$\textbf{[seed]} \quad \lambda P.\lambda C.\lambda \vec{x}.P(\vec{x}) : \underline{[\langle\vec{\alpha}\rangle_n \multimap \downarrow_{\sigma\langle t\rangle}]} \multimap [(\uparrow_\sigma \textsc{coord-rel}) \multimap \underline{[\langle\vec{\alpha}\rangle_n \multimap \uparrow_{\sigma\langle t\rangle}]}]$$

In (73), the expression $\langle\vec{\alpha}\rangle_n$ represents a sequence of *n* (zero or more) dependents that are shared across the conjuncts of the coordinate structure; $\vec{x}$ represents the corresponding meanings. Importantly, the number of required dependents for the seed conjunct is inherited by the coordinate structure as a whole, and the fact that the **[conj]** macro consumes a resource requiring *n* dependents and produces a resource which also requires *n* dependents ensures that valency requirements for all conjuncts are shared. Thus, semantic completeness and coherence (Chapter 8, Section 7.1) ensures that requirements for each conjunct are met, with no surplus resources remaining. For instance, the ungrammaticality of (65) (*Chris selected and arrived Tracy*) is due to a mismatch of valency requirements. The seed conjunct *arrived* requires only a SUBJ argument, and the schema is instantiated so that the seed conjunct shares the requirement for a SUBJ argument (and no other arguments) with the coordinate structure as a whole; the non-seed conjuncts must match this requirement. The result is that the two verbs *selected* and *arrived* share a SUBJ but not an OBJ: the resource for *Tracy* is left unused, violating semantic coherence, and the requirement imposed by *selected* for an OBJ resource is not met, violating semantic completeness.

As before, these templates are used in the final definitions of the rule macros for coordinate structures with conjoinable types.

(74) a. Final definition of the rule macro CNJ(_c):

$$\textsc{cnj}(\_c) \equiv \quad \begin{array}{c}\text{Cnj[main]}\\ \uparrow = \downarrow\end{array} \quad \begin{array}{c}\_c\\ \downarrow\in\uparrow\\ \textbf{[conj]}\end{array}$$

b. Final definition of the rule macro FINAL-CNJ(_c):

$$\textsc{final-cnj}(\_c) \equiv \quad \begin{array}{c}\text{Cnj[main]}\\ \uparrow = \downarrow\end{array} \quad \begin{array}{c}\_c\\ \downarrow\in\uparrow\\ \textbf{[seed]}\end{array}$$

c. Final rule macro for English coordination:

$$\textsc{english-coord}(\_c) \equiv$$

$$\begin{pmatrix}\text{Cnj[pre]}\\ \uparrow = \downarrow\end{pmatrix} \quad \begin{array}{c}\_c\\ \downarrow\in\uparrow\\ \textbf{[conj]}\end{array} \quad \left\{ \begin{array}{c}\_c^*\\ \downarrow\in\uparrow\\ \textbf{[conj]}\end{array} \middle| \quad @\textsc{cnj}(\_c)^* \quad \right\} \quad @\textsc{final-cnj}$$

This macro allows any dependent that is shared across a coordinate structure to satisfy the requirements of each conjunct.

Asudeh and Crouch (2002a) discuss a very similar general coordination schema to the templates in (73), and present two objections to the resulting analysis. First, they point out that not all coordination involves conjoinable types; in particular, it has been argued that nominal coordination works differently, and cannot be captured by this rule schema. We are in agreement with this observation, and in Section 8.3 we propose a different set of templates for nominal conjunction; however, this does not constitute motivation for abandoning the analysis of conjoinable types which we have presented in this section. Second, they propose that more control over the types involved in coordination is available if a coordination rule is separately specified for each c-structure category. However, there is no one-to-one relation between c-structure categories and semantic types: for example, in V coordination, the type of the coordinate structure depends on the type of the verb ($\langle e \rightarrow t \rangle$ for intransitive verbs, $\langle \langle e \rightarrow t \rangle \rightarrow t \rangle$ for transitive verbs, and so on). This means that a rule schema like (74) is needed even if separate rules are proposed for each c-structure category, and we do not see any advantage to proposing a separate schema for each c-structure category over the general schema in (74). Thus, we do not consider either of these objections as counting against this approach.

8. NOUN PHRASE COORDINATION

Syntactically, noun phrase coordination is similar to clausal coordination in that it involves set formation at f-structure, with the f-structures of the conjuncts as members of the set. It differs from clausal coordination in several repects. First, as discussed in Chapter 2, Section 5.7.1, a coordinate noun phrase has its own INDEX features, which may be different from the INDEX features of its conjuncts. We discuss the features of coordinated nominal phrases in Section 8.1, building on our discussion of f-structure features in Chapter 2, Section 5. Like simple noun phrases, a coordinate noun phrase can be the controller of agreement: in some cases, agreement depends on the resolved (Section 8.1.1) features of the coordinate noun phrase, while in other cases one of the conjuncts in the coordinate structure (the 'distinguished conjunct') controls agreement (Section 8.1.2).

Semantically, noun phrase coordination differs from clausal coordination in involving group formation. We discuss the semantics of noun phrase coordination in Section 8.2, and provide a glue-based treatment in Section 8.3.

8.1. Nominal Features in Coordination

As discussed in Chapter 6, Section 3.2, a coordinate noun phrase has features that may differ from the features of the individual conjunct phrases: these are *nondistributive* features. Besides possibly having both the features PRECONJ and CONJ contributed by the preconjunction and conjunction, a coordinated noun phrase has an INDEX feature encoding the resolved person, number, and gender features of the coordinate phrase.

Agreement relations may depend on either the resolved syntactic INDEX features of a coordinate phrase or the features of a 'distinguished' conjunct; see Hristov

(2012) for an overview discussion. Additionally, agreement with a coordinate noun phrase is sometimes partially or completely semantically based, in which case it does not depend on syntactic features of the coordinate structure or a distinguished conjunct alone or possibly at all. Sadler (2006) proposes a feature-based analysis of complex gender resolution patterns in Romanian, and Wechsler (2008) proposes a set-based analysis of gender resolution in French; both authors show that a distinction between syntactic and semantic resolution is vital to an adequate analysis of GEND resolution in these languages. In the following, we focus on the INDEX feature bundle and syntactic feature resolution.

8.1.1. Feature Resolution in Coordination: PERS and GEND

In Chapter 2, Section 5.7, we discussed nominal features and theories of representation and resolution for person and gender features. Resolution patterns for the PERS feature are:

(75) Resolution of the PERS feature

first & second	= first
first & third	= first
second & third	= second
third & third	= third

Our theory of the representation of the values of the PERS feature must account for this pattern. As discussed in Chapter 2, Section 5.7.2, Dalrymple and Kaplan (2000) and Vincent and Börjars (2007) adopt a set-based representation of the PERS feature, as shown in (76). Sadler (2011) demonstrates that any set-based analysis of complex feature values can be directly translated to an equivalent feature-based analysis, with a positive value representing the presence of an element in the set, and a negative value representing its absence.

(76) Values of the PERS feature

	Set-based value	Feature-based equivalent
1:	$\{\textsc{s},\textsc{h}\}$	$\begin{bmatrix}\textsc{pers} & \begin{bmatrix}1 & + \\ 2 & +\end{bmatrix}\end{bmatrix}$
2:	$\{\textsc{h}\}$	$\begin{bmatrix}\textsc{pers} & \begin{bmatrix}1 & - \\ 2 & +\end{bmatrix}\end{bmatrix}$
3:	$\{\}$	$\begin{bmatrix}\textsc{pers} & \begin{bmatrix}1 & - \\ 2 & -\end{bmatrix}\end{bmatrix}$

If we assume a set-based theory of the values of the PERS feature, treating resolution as set union of the values of the PERS features of the conjuncts produces the same pattern as in (75), as desired:

(77) Resolution of the PERS feature via set union

$$\begin{array}{rl}
\{\text{S,H}\}\ (\text{first}) \cup \{\text{H}\}\ (\text{second}) & = \{\text{S,H}\}\ (\text{first}) \\
\{\text{S,H}\}\ (\text{first}) \cup \{\}\ (\text{third}) & = \{\text{S,H}\}\ (\text{first}) \\
\{\text{H}\}\ (\text{second}) \cup \{\}\ (\text{third}) & = \{\text{H}\}\ (\text{second}) \\
\{\}\ (\text{third}) \cup \{\}\ (\text{third}) & = \{\}\ (\text{third})
\end{array}$$

In the following, we show how to define resolution rules for the PERS feature in a feature-based setting, preserving the essential intuitions underlying the union operation while retaining the advantages of a feature-based analysis, including underspecification.

'UNION' IN A FEATURE-BASED ANALYSIS: Given a feature-based representation of the value of the PERS feature, resolution rules must have the same effect as the union analysis; if the value of the attributes 1 or 2 is + for any conjunct daughter, the coordinate structure as a whole has the value + for that attribute:

(78) Resolution of the PERS feature in a feature-based approach

$$\begin{array}{llllll}
\left[\text{PERS} \begin{bmatrix} 1 & + \\ 2 & + \end{bmatrix}\right] (\text{first}) & \& & \left[\text{PERS} \begin{bmatrix} 1 & - \\ 2 & + \end{bmatrix}\right] (\text{second}) & = & \left[\text{PERS} \begin{bmatrix} 1 & + \\ 2 & + \end{bmatrix}\right] (\text{first}) \\[2ex]
\left[\text{PERS} \begin{bmatrix} 1 & + \\ 2 & + \end{bmatrix}\right] (\text{first}) & \& & \left[\text{PERS} \begin{bmatrix} 1 & - \\ 2 & - \end{bmatrix}\right] (\text{third}) & = & \left[\text{PERS} \begin{bmatrix} 1 & + \\ 2 & + \end{bmatrix}\right] (\text{first}) \\[2ex]
\left[\text{PERS} \begin{bmatrix} 1 & - \\ 2 & + \end{bmatrix}\right] (\text{second}) & \& & \left[\text{PERS} \begin{bmatrix} 1 & - \\ 2 & - \end{bmatrix}\right] (\text{third}) & = & \left[\text{PERS} \begin{bmatrix} 1 & - \\ 2 & + \end{bmatrix}\right] (\text{second}) \\[2ex]
\left[\text{PERS} \begin{bmatrix} 1 & - \\ 2 & - \end{bmatrix}\right] (\text{third}) & \& & \left[\text{PERS} \begin{bmatrix} 1 & - \\ 2 & - \end{bmatrix}\right] (\text{third}) & = & \left[\text{PERS} \begin{bmatrix} 1 & - \\ 2 & - \end{bmatrix}\right] (\text{third})
\end{array}$$

In (78), the resolved value in the third column has a + value for the attribute 1 or 2 whenever one or both of the conjuncts has the value + for that attribute.

In order to impose the proper constraints, we define the following basic template, which we call PLUS:[15]

(79) $$\text{PLUS}(\_\text{SET}, \_\text{PATH}) \equiv \begin{array}{l} (\_\text{SET} \in \_\text{PATH}){=}+ \Rightarrow (\_\text{SET}\ \_\text{PATH}){=}+ \\ (\_\text{SET} \in \_\text{PATH}) \neq + \Rightarrow (\_\text{SET}\ \_\text{PATH}){=}- \end{array}$$

In this definition, _SET is a set of f-structures and _PATH is a sequence of f-structure attributes. The template requires that if a member (∈) of the set _SET has a positive value (+) for _PATH, then the set itself has a positive value (+) for _PATH. If no member has the value + for _PATH, the set has the negative value (−) for _PATH.

[15] See Chapter 5, Section 2.10 for discussion of implicational constraints using the ⇒ operator; see Chapter 6, Section 3.1 for an explanation of the symbol ∈ used as an attribute.

Given this definition, the template call in (80a) is exactly equivalent to the fully specified set of constraints in (80b), requiring that if any member of the set of f-structures $\uparrow$ has the value + for the 1 attribute in the INDEX PERS feature bundle, then the set $\uparrow$ has the value + for INDEX PERS 1, and otherwise the set $\uparrow$ has the value − for INDEX PERS 1. This produces the correct result for the resolution patterns in (78).

(80) a. $@\textsc{plus}(\uparrow, \textsc{index pers}\ 1)$

b. $(\uparrow \in \textsc{index pers}\ 1) {=} + \Rightarrow (\uparrow\ \textsc{index pers}\ 1) = +$
$(\uparrow \in \textsc{index pers}\ 1) \neq + \Rightarrow (\uparrow\ \textsc{index pers}\ 1) = -$

We can now define a template @PERS-RES which ensures the correct PERS resolution patterns: if any conjunct has a positive value for the 1 or 2 attributes of the PERS feature, the set as a whole has a positive value for that attribute. Otherwise, the set has a negative value for that attribute.

(81) $\textsc{pers-res}(\_\textsc{set}) \equiv @\textsc{plus}(\_\textsc{set}, \textsc{index pers}\ 1)$
$\qquad\qquad\qquad\qquad @\textsc{plus}(\_\textsc{set}, \textsc{index pers}\ 2)$

In this definition, _SET is a set of f-structures representing a coordinate structure, with the conjuncts as members of the set. The template requires that the value of INDEX PERS 1 for the coordinate structure is + if any of the conjuncts has the value + for INDEX PERS 1, and − otherwise. The same pattern holds for INDEX PERS 2.

By the use of these templates, we can preserve the intuitions and advantages of the union analysis of resolution for the PERS feature while also retaining the advantages of the feature-based approach.

We specify the PERS-RES template as an additional constraint in the phrase structure rule for nominal coordination. In (82) we define a new rule macro ENGLISH-NCOORD for nominal coordination, which we also use in our discussion of the semantics of nominal coordination in Section 8.2. For explicitness, we associate the PERS-RES template with the final conjunct, but since the template refers only to the f-structure $\uparrow$, it could appear on any of the daughters.

(82) Rule macro for English nominal coordination including person resolution constraints:

$\textsc{english-ncoord}(\_c) \equiv$

$$\begin{pmatrix}\text{Cnj[pre]}\\ \uparrow = \downarrow\end{pmatrix} \quad \begin{array}{c}\_c\\ \downarrow\in\uparrow\end{array} \quad \left\{ \begin{array}{c}\_c^{*}\\ \downarrow\in\uparrow\end{array} \;\middle|\; \begin{array}{c}@\textsc{cnj}(\_c)^{*}\\ \ \end{array} \right\} \quad \begin{array}{c}@\textsc{cnj}(\_c)\\ @\textsc{pers-res}(\uparrow)\end{array}$$

'INTERSECTION' IN A FEATURE-BASED ANALYSIS: As discussed in Chapter 2, Section 5.7.3, set values have also been proposed for the GEND feature, with resolution modeled as either union (Dalrymple and Kaplan 2000) or intersection (Vincent and Börjars 2007). Corbett (1983) proposes the following generalization for gender resolution in Icelandic.

(83) Gender resolution in Icelandic:

If the conjuncts are all masculine, the masculine form is used.

If the conjuncts are all feminine, the feminine form is used.

Otherwise the neuter form is used.

Vincent and Börjars (2007) propose a set-based treatment of gender resolution, relying on the values in (84) for the GEND feature.

(84) Values for the GEND feature in Icelandic according to Vincent and Börjars (2007):

masculine:	{M}
feminine:	{F}
neuter:	{ }

Given these set values, gender resolution can be modeled as set intersection.

(85) Resolution of the GEND feature as set intersection (Vincent and Börjars 2007):

$$\begin{array}{rl}
\{\text{M}\}\ (\text{masculine}) \cap \{\text{M}\}\ (\text{masculine}) & = \{\text{M}\}\ (\text{masculine}) \\
\{\text{F}\}\ (\text{feminine}) \cap \{\text{F}\}\ (\text{feminine}) & = \{\text{F}\}\ (\text{feminine}) \\
\{\ \}\ (\text{neuter}) \cap \{\ \}\ (\text{neuter}) & = \{\ \}\ (\text{neuter}) \\
\{\text{M}\}\ (\text{masculine}) \cap \{\text{F}\}\ (\text{feminine}) & = \{\ \}\ (\text{neuter}) \\
\{\text{M}\}\ (\text{masculine}) \cap \{\ \}\ (\text{neuter}) & = \{\ \}\ (\text{neuter}) \\
\{\text{F}\}\ (\text{feminine}) \cap \{\ \}\ (\text{neuter}) & = \{\ \}\ (\text{neuter})
\end{array}$$

In a feature-based setting, the corresponding values for masculine, feminine, and neuter gender are as in (86), with a positive (+) value representing the presence of a set element, and a negative (−) value representing its absence; as discussed by Dalrymple and Kaplan (2000) and Vincent and Börjars (2007), fewer or more features may be necessary when analyzing simpler or more complex gender systems.

(86) Feature-based values for the GEND feature in Icelandic:

$$\text{masculine:} \quad \begin{bmatrix} \text{M} & + \\ \text{F} & - \end{bmatrix}$$

$$\text{feminine:} \quad \begin{bmatrix} \text{M} & - \\ \text{F} & + \end{bmatrix}$$

$$\text{neuter:} \quad \begin{bmatrix} \text{M} & - \\ \text{F} & - \end{bmatrix}$$

In order to produce the same effect as set intersection in a feature-based setting, we first define a macro which we call MINUS:

(87) $$\text{MINUS(\_SET, \_PATH)} \equiv \begin{array}{l} (\text{\_SET} \in \text{\_PATH}) \neq - \Rightarrow (\text{\_SET \_PATH}) = + \\ (\text{\_SET} \in \text{\_PATH}) = - \Rightarrow (\text{\_SET \_PATH}) = - \end{array}$$

In this definition, _SET is a set of f-structures and _PATH is a sequence of f-structure attributes. The template specifies that if no member of the set _SET has a negative value − for _PATH (in this case, all of the members of the set have the value + for _PATH), then the set itself has the value + for _PATH. If any member has the negative value − for _PATH, the set itself has the negative value − for _PATH.

We can make use of the template MINUS to define a gender resolution template GEND-RES for Icelandic; additional constraints may be needed for languages with more complex gender systems.

(88) GEND-RES(_SET) ≡ @MINUS(_SET, INDEX M)
@MINUS(_SET, INDEX F)

In this definition, _SET is a set of f-structures. The template requires that the value of INDEX M for the set is + if all of the conjuncts have the value + for INDEX M, and − otherwise. The same pattern holds for INDEX F.

The gender resolution template in (88) is associated with one of the conjuncts in the Icelandic nominal coordination rule; because the template refers only to the mother f-structure ↑, it can be associated with any of the conjuncts.

8.1.2. Distinguished Conjunct Agreement

Agreement with coordinate noun phrases often depends on the syntactic or semantic features of the coordinate phrase; however, other patterns are also found. Sadler (1999, 2003) was among the first to propose an LFG-based analysis of *distinguished conjunct agreement*, constructions in which the controller of agreement is one of the conjuncts of a coordinate phrase. The distinguished conjunct is either the initial or the final conjunct: often (but not always), it is the conjunct that is closest to the agreement target (the initial conjunct if the agreement target precedes the coordinate phrase, and the final conjunct if it follows the coordinate phrase), and so this agreement pattern is sometimes called “closest conjunct agreement”.

Sadler (1999, 2003) examines agreement patterns in Welsh, a VSO language in which only pronominals control agreement: the verb agrees with the pronominal subject in (89a), and shows default (third person singular) agreement in (89b).

(89) a. *Daethan (nhw).*
came.3PL (they)
‘They came.’

b. *Daeth y dynion.*
came.3SG the men
‘The men came.’

With coordinated subjects, verb agreement does not reflect the resolved features of the coordinate phrase; instead, the verb agrees with the initial conjunct if it is pronominal (examples 90a,b) and shows default agreement otherwise (example 90c).

(90) a. *Daethost ti a minnau/Siôn.*
came.2SG you and I/Siôn
'You and I/Siôn came.'

b. *Roeddwn i a Mair i briodi.*
was.1SG 1SG and Mair to marry
'I and Mair were to marry.'

c. *Roedd Mair a fi i briodi.*
was.3SG Mair and 1SG to marry
'Mair and I were to marry.'

A potential (but incorrect) analysis of these patterns is that verb agreement does in fact reflect the features of the coordinate structure as a whole, but that in examples like (90), the coordinate structure is unexpectedly associated with the features of just one of its conjuncts, rather than the resolved features. For example, on this view the coordinate phrase *i a Mair* 'I and Mair' in (90b) would have the features of a first person singular phrase, matching the features of the initial conjunct.

Sadler (2003) demonstrates convincingly that such an analysis is not viable, showing that distinguished conjunct agreement patterns as in (90) can coexist in the same clause with resolved agreement patterns. In (91), the passive auxiliary *chaffodd* shows third person singular (distinguished conjunct) agreement with the initial conjunct *e* 'he', while the non-finite main verb is preceded by an anaphoric form *eu* showing third person plural (resolved) agreement with the coordinate phrase *e a'i milwyr* 'he and his soldiers':

(91) *Ni chaffodd e a'i milwyr eu lladd yma.*
NEG got.3SG he and-3SG.M soldiers 3PL kill there
'He and his soldiers were not killed there.'

Similarly, in (92) the verb *gwelais* shows first person singular (distinguished conjunct) agreement with the initial conjunct *i* 'I', and the reflexive anaphor *ein hunain* shows first person plural (resolved) agreement with the coordinate phrase *i a'm brawd* 'I and my brother':

(92) *Gwelais i a'm brawd ein hunain.*
saw.1SG I and.1SG brother 1PL self
'I and my brother saw ourselves.'

Thus, the coordinate phrase must be analyzed as having the expected resolved features rather than the features of one of the conjuncts, since the resolved features are referenced in auxiliary agreement in (91) and anaphoric agreement in (92).

Arnold et al. (2007) provide an in-depth discussion of Brazilian Portuguese data that show even more complex patterns. Brazilian Portuguese allows resolved agreement with the features of a coordinate structure as well as distinguished conjunct agreement with the initial conjunct or the final conjunct. Arnold et al. provide (93) to show that distinguished conjunct agreement with different conjuncts can coexist in the same structure; a prenominal determiner can exhibit distinguished conjunct agreement with the initial conjunct, while a postnominal adjective can exhibit distinguished conjunct agreement with the final conjunct:

(93) *os* *corações* *e* *mentes* *brasileiras*
the.M.PL hearts.M.PL and minds.F.PL Brazilian.F.PL
'the Brazilian hearts and minds'

Thus, our theory must allow reference to the syntactic and semantic features of a coordinated noun phrase (in resolved agreement), as well as the syntactic and semantic features of the initial and final conjuncts (in distinguished conjunct agreement).

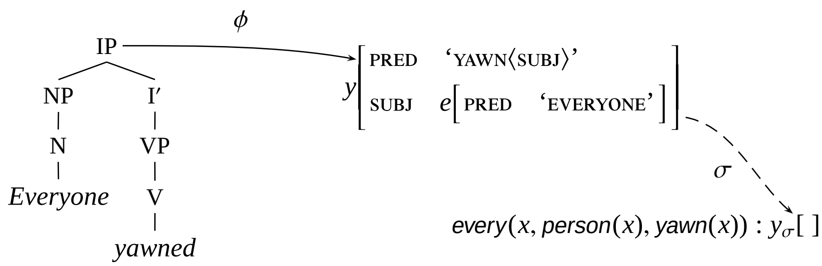
Kuhn and Sadler (2007) review earlier proposals for the treatment of distinguished conjunct agreement, dividing them into *representation-based approaches* and *description-based approaches*. Representation-based approaches augment the f-structure of coordinate nominal phrases with additional features to encode agreement information for the distinguished conjunct. Kuhn and Sadler (2007) discuss several problems with representation-based approaches: these additional features are purely for bookkeeping, and introduce unneeded complexity into the f-structure representation; further, features for both the initial conjunct and the final conjunct would be needed to handle examples like the Brazilian Portuguese example in (93), where material on the left agrees with the initial conjunct, and material on the right agrees with the final conjunct. Kuhn and Sadler (2007) propose a description-based approach which introduces a new kind of structure, a *local f-structure sequence*, in the representation of coordinate structures; they also propose an expanded classification of f-structure features as left-peripheral, right-peripheral, or proximity-based, in addition to the standard distributive/nondistributive classification. Dalrymple and Hristov (2010) build on Kuhn and Sadler's insights in a revised proposal that does not depend on an enriched feature classification, but allows constructional specification of agreement requirements as referring to the initial or final conjunct.

8.2. Semantics of Noun Phrase Coordination

Much work has been done on the semantics of coordinated noun phrases. A clearly presented and useful overview is given by Winter (2001); as he notes, approaches to nominal coordination generally fall into two categories. The first type of analysis assumes that conjunctions such as *and* are ambiguous, making different semantic contributions in coordinating conjoinable types ('ending in *t*') and in nominal coordination, while the second type of analysis (advocated by Winter 2001) assumes that there is only one semantic contribution for *and* regardless of whether it coordinates clausal or nominal phrases. The prospect of a uniform analysis of coordination is explored in very interesting work by Winter (1998, 2001), Champollion (2016), and others. However, these analyses postulate a variety of unpronounced operators to shift and augment the meaning of the nominal conjuncts in various ways, and it is not yet clear whether any or all of these unpronounced operators are necessary or desirable in a glue setting. In the following, we explore a constructional analysis that treats some cases of nominal coordination as 'group-forming', combining individuals of type *e* to produce a new *e*-type individual, while also preserving the standard meanings of *and* and *or* (see also Partee and Rooth 1983, Appendix B; Hoeksema 1988).[16]

In fact, treating coordination of 'conjoinable types' (types 'ending in *t*') differently from at least some cases of nominal coordination is a natural move in the context of the glue approach to the syntax-semantics interface and the treatment of quantifiers discussed in Chapter 8, since it allows us to treat coordination involving quantifiers in the same way as coordination of non-quantifiers, without any necessary modification to the treatment of quantification and scope. Recall the glue treatment of quantifiers such as *everyone* or *every student*, illustrated in (65), Chapter 8, Section 8.1.2, repeated here with the types explicitly indicated.

(94) *Everyone yawned.*



$$\textbf{[everyone]} \quad \lambda S.\mathit{every}(x, \mathit{person}(x), S(x)) \;:\; \forall H_{\langle t\rangle}.[e_{\sigma\langle e\rangle} \multimap H_{\langle t\rangle}] \multimap H_{\langle t\rangle}$$

$$\textbf{[yawn]} \quad \lambda z.\mathit{yawn}(z) \;:\; e_{\sigma\langle e\rangle} \multimap y_{\sigma\langle t\rangle}$$

Notably, the semantic structure e_σ for the NP *everyone* corresponds to the *e*-type variable bound by the quantifier: it is a syntactically accessible reflex of the *e*-type component of a quantifier meaning. When a quantifier appears as a conjunct in nominal coordination, it is the *e*-type component of its meaning that corresponds to the syntactic structure involved in coordination. This means that our proposal does not require the complicated machinery for meaning assembly in quantifier coordination which is required by other analyses, including Hoeksema (1988).

We adopt a variant of Asudeh and Crouch's (2002a) proposed semantics for *e*-type coordination:

(95) a. *David and Tracy met.*

$$\exists X.\mathit{David} \leq X \wedge \mathit{Tracy} \leq X \wedge \mathit{meet}(X)$$

[16]Not all cases of nominal coordination are best treated as group-forming; a standard example which must be treated as conjunction of predicates is *the president and CEO*, which refers to a single individual who is both the president and the CEO ($\mathit{the}(x.\mathit{president}(x) \wedge \mathit{CEO}(x))$). For discussion of such examples, see Bergmann (1982), Dowty (1988), King and Dalrymple (2004), and Heycock and Zamparelli (2005), among others.

b. *David or Tracy yawned.*

$\exists X.\mathit{David} \leq X \vee \mathit{Tracy} \leq X \wedge \mathit{yawn}(X)$

Here, the coordinate structure introduces a possibly complex individual X of type e. In (95a), X is composed of the atomic e-type individuals *David* and *Tracy*, while in (95b), X is either the individual *David* or the individual *Tracy*. We do not take a position on the precise interpretation of the 'part-of' relation $\leq$ in (95); according to Link's (1983) lattice-theoretic treatment, it can be interpreted as the 'individual part' relation, so that in (95a), the group X is the plural individual $\mathit{David} \otimes \mathit{Tracy}$. Landman (1989) and Schwarzschild (1994) provide more discussion of this issue and an alternative view.

As we will see, this proposal extends straightforwardly to cases in which indefinite singulars are coordinated. We propose this meaning for the sentence *A student and a professor met*:

(96) *A student and a professor met.*

$a(x, \mathit{student}(x),\ a(y, \mathit{professor}(y), \exists X.x \leq X \wedge y \leq X \wedge \mathit{meet}(X)))$

This sentence means that a group consisting of the individuals x and y met, where x is a student and y is a professor. We can also coordinate a proper name with an indefinite:

(97) *David and a professor met.*

$a(y, \mathit{professor}(y), \exists X.\mathit{David} \leq X \wedge y \leq X \wedge \mathit{meet}(X))$

Here, the group that met consists of y, a professor, and the individual *David*.

This approach works well for these simple cases. As noted by Schwarzschild (1994, page 22), complications arise in the treatment of other cases; in particular, the quantifier *no* is problematic:

(98) *No soldier and no officer met.*

Does not mean:
$\mathit{no}(x, \mathit{soldier}(x),\ \mathit{no}(y, \mathit{officer}(y), \exists X.x \leq X \wedge y \leq X \wedge \mathit{meet}(X)))$

The meaning representation given in (98) can be paraphrased as 'There is no soldier that met no officer' (that is, 'Every soldier met some officer'), clearly not a possible meaning for this sentence. In fact, the scoping problem posed by this example can be circumvented if (98) is analyzed as an instance of *branching quantification* (Barwise 1979), in which neither quantifier takes scope over the other; many examples that have been taken to exemplify branching quantification involve coordinated noun phrases. We will not attempt to provide a full analysis of these cases here, but will restrict ourselves to providing an analysis of the simpler cases, in the belief that getting a firm handle on simpler cases of noun phrase coordination will ultimately enable a more revealing analysis of those cases that are more complex. For discussion of the semantics of noun phrase coordination and plurality, see Krifka (1990), Schwarzschild (1994), Lasersohn

(1995), Winter (1998, 2006), Champollion (2016), and references cited in those works.

8.3. Noun Phrase Coordination and Meaning Assembly

The f-structure and meaning constructor for the sentence *David and Tracy met* are:

(99) *David and Tracy met.*

$$m\left[\begin{array}{ll}\textsc{pred} & \text{‘}\textsc{meet}\langle\textsc{subj}\rangle\text{’}\\ \textsc{subj} & a\left[\begin{array}{ll}\textsc{num} & \textsc{pl}\\ \textsc{conj} & \textsc{and}\\ \multicolumn{2}{l}{\left\{\begin{array}{l} d\left[\begin{array}{ll}\textsc{pred} & \text{‘David’}\end{array}\right]\\ t\left[\begin{array}{ll}\textsc{pred} & \text{‘Tracy’}\end{array}\right]\end{array}\right\}}\end{array}\right]\end{array}\right] \overset{\sigma}{\dashrightarrow} a_\sigma\left[\begin{array}{ll}\textsc{coord-rel} & c[\;]\\ \textsc{coord-restr} & cr[\;]\end{array}\right]$$

$$\exists X.\mathit{David} \leq X \wedge \mathit{Tracy} \leq X \wedge \mathit{meet}(X) : m_\sigma$$

As with our analysis of clausal coordination, we assume that one of the conjuncts is the seed; again, we treat the final conjunct as the seed, though nothing depends on this choice. The meanings of the non-seed conjuncts are then added to the meaning of the coordinate structure one by one. Partee and Rooth (1983) note that it is not generally assumed that there are ‘*e*-conjoinable’ types (types ‘ending in *e*’) other than *e* itself (in particular, Montague (1973) does not propose any additional ‘*e*-conjoinable’ types), so we provide only the definition for *e*-type conjunction here, and do not allow for complex types ‘ending in *e*’.

The meaning for (99) has a structure similar to a generalized quantifier, with constraints on the composition of X analogous to the restriction of the quantifier, and the predication on X as its scope (Chapter 8, Section 4.1.4). Thus, for nominal coordination we introduce a semantic structure attribute COORD-RESTR of type t, associated with constraints on the composition of the group X (for example, that *David* and *Tracy* are individual parts of X). There are two meaning constructors associated with the seed, which we call **[nseed1]** and **[nseed2]**. The meaning constructor **[nseed1]** requires the meaning of the seed conjunct (here, *Tracy*) to be a component of the coordinate structure meaning X. The meaning constructor **[nconj]** is associated with the non-seed conjuncts (here, there is only one non-seed conjunct, *David*) and asserts that the meanings of each of the non-seed conjuncts are also components of the meaning of the coordinate structure. Finally, the meaning constructor **[nseed2]** consumes the COORD-RESTR meaning and its dependency on the coordinate structure $\uparrow_\sigma$, producing a quantifier meaning ($[\uparrow_{\sigma\langle e\rangle} \multimap S] \multimap S$) which combines the coordinate structure with its predicate (here, *meet*).

(100) a. Meaning constructor for non-seed nominal conjuncts:

[nconj] $\lambda x.\lambda Q.\lambda C.\lambda X.C(x \leq X, Q(C, X))$:
$\downarrow_{\sigma\langle e\rangle} \multimap [(\uparrow_\sigma \textsc{coord-rel}) \multimap [\uparrow_{\sigma\langle e\rangle} \multimap (\uparrow_\sigma \textsc{coord-restr})]] \multimap [(\uparrow_\sigma \textsc{coord-rel}) \multimap [\uparrow_{\sigma\langle e\rangle} \multimap (\uparrow_\sigma \textsc{coord-restr})]]$

b. First meaning constructor for seed nominal conjunct:

[nseed1] $\lambda x.\lambda C.\lambda X.x \leq X : \downarrow_{\sigma\langle e\rangle} \multimap [(\uparrow_\sigma \textsc{coord-rel}) \multimap [\uparrow_{\sigma\langle e\rangle} \multimap (\uparrow_\sigma \textsc{coord-restr})]]$

c. Second meaning constructor for seed nominal conjunct:

[nseed2] $\lambda P.\lambda Q.\exists X.P(X) \wedge Q(X) : [\uparrow_{\sigma\langle e\rangle} \multimap (\uparrow_\sigma \textsc{coord-restr})] \multimap [\uparrow_{\sigma\langle e\rangle} \multimap S] \multimap S$

d. Definition of the rule macro NCNJ(_c):

$$\textsc{ncnj}(\_c) \equiv \quad \begin{array}{c} \text{Cnj[main]} \\ \uparrow = \downarrow \end{array} \quad \begin{array}{c} \_c \\ \downarrow \in \uparrow \\ \textbf{[nconj]} \end{array}$$

e. Definition of the rule macro FINAL-NCNJ(_c), including person and gender resolution macros (Section 8.1.1):

$$\textsc{final-ncnj}(\_c) \equiv \quad \begin{array}{c} \text{Cnj[main]} \\ \uparrow = \downarrow \\ \\ \\ \\ \\ \end{array} \quad \begin{array}{c} \_c \\ \downarrow \in \uparrow \\ \textbf{[nseed1]} \\ \textbf{[nseed2]} \\ @\textsc{pers-res}(\uparrow) \\ @\textsc{gend-res}(\uparrow) \end{array}$$

f. Full rule macro for English nominal coordination:

$$\textsc{english-ncoord}(\_c) \equiv$$

$$\left(\begin{array}{c} \text{Cnj[pre]} \\ \uparrow = \downarrow \end{array}\right) \quad \begin{array}{c} \_c \\ \downarrow \in \uparrow \\ \textbf{[nconj]} \end{array} \quad \left\{ \begin{array}{c} \_c^* \\ \downarrow \in \uparrow \\ \textbf{[nconj]} \end{array} \;\middle|\; @\textsc{ncnj}(\_c)^* \right\} \quad @\textsc{final-ncnj}(\_c)$$

Thus, we have the following deduction of the meaning of *David and Tracy met*, using the f-structure labels introduced in (99):

(101) $\mathsf{David} : d_\sigma$

This is the meaning constructor **[David]**. It associates the meaning David with the semantic structure d_σ.

$\lambda x.\lambda Q.\lambda C.\lambda X.C(x \leq X, Q(C, X)) : d_\sigma \multimap [[c \multimap [a_\sigma \multimap cr]] \multimap [c \multimap [a_\sigma \multimap cr]]]$

This is the meaning constructor **[nconj]**. It consumes the resource for the conjunct *David* and produces a modifier of the COORD-RESTR meaning *cr*, which itself depends on the meaning of the conjunction *c* and the meaning of a_σ.

$\lambda Q.\lambda C.\lambda X.C(\mathsf{David} \leq X, Q(C, X)) : [[c \multimap [a_\sigma \multimap cr]] \multimap [c \multimap [a_\sigma \multimap cr]]]$

Combining **[David]** and **[nconj]**, we have this meaning constructor, which we call **[David-conj]**.

$\mathsf{Tracy} : t_\sigma$

This is the meaning constructor **[Tracy]**. It associates the meaning Tracy with the semantic structure t_σ.

$\lambda x.\lambda C.\lambda X.x \leq X : t_\sigma \multimap [c \multimap [a_\sigma \multimap cr]]$

This is the meaning constructor **[nseed1]**. It consumes the resource for the seed conjunct *Tracy* to produce a meaning for the COORD-RESTR meaning *cr* which depends on *c* and a_σ.

$\lambda C.\lambda X.\mathsf{Tracy} \leq X : [c \multimap [a_\sigma \multimap cr]]$

Combining **[Tracy]** and **[nseed1]**, we have this meaning constructor, which we call **[Tracy-conj]**.

$\lambda C.\lambda X.C(\mathit{David} \leq X, \mathit{Tracy} \leq X) : c \multimap [a_\sigma \multimap cr]$

Combining **[David-conj]** and **[Tracy-conj]**, we have this meaning constructor, which we call **[David-Tracy-conj]**.

$\wedge : c$

This is the meaning constructor **[and]**. It provides the meaning $\wedge$ contributed by the conjunction *and*.

$\lambda X.\mathit{David} \leq X \wedge \mathit{Tracy} \leq X : a_\sigma \multimap cr$

Combining **[David-Tracy-conj]** and **[and]**, we have this meaning constructor, which we call **[David-and-Tracy]**.

$\lambda P.\lambda Q.\exists X.P(X) \wedge Q(X) : [a_\sigma \multimap cr] \multimap [a_\sigma \multimap S\,] \multimap S$

This is the meaning constructor **[nseed2]**.

$\lambda Q.\exists X.\mathit{David} \leq X \wedge \mathit{Tracy} \leq X \wedge Q(X) : [a_\sigma \multimap S\,] \multimap S$

Combining **[David-and-Tracy]** and **[nseed2]**, we have this meaning constructor, which we call **[David-and-Tracy-quant]**.

$\lambda x.\mathit{meet}(x) : a_\sigma \multimap m_\sigma$

This is the meaning constructor **[meet]**.

$\exists X.\mathit{David} \leq X \wedge \mathit{Tracy} \leq X \wedge \mathit{meet}(X) : m_\sigma$

Combining **[David-and-Tracy-quant]** and **[meet]**, we have produced the desired meaning for the sentence.

Next we consider (102), which differs from the example just discussed in that a quantifier is coordinated with a proper name:

(102) *David and a professor met.*

$$m\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{meet}\langle\textsc{subj}\rangle\text{’} \\ \textsc{subj} & a\left[\begin{array}{ll} \textsc{num} & \textsc{pl} \\ \textsc{conj} & \textsc{and} \\ \multicolumn{2}{l}{\left\{\begin{array}{l} d\left[\begin{array}{ll} \textsc{pred} & \text{‘David’} \end{array}\right] \\ p\left[\begin{array}{ll} \textsc{def} & - \\ \textsc{pred} & \text{‘}\textsc{professor}\text{’} \end{array}\right] \end{array}\right\}} \end{array}\right] \end{array}\right]$$

$$\mathit{a}(y, \mathit{professor}(y), \exists X.\mathit{David} \leq X \wedge y \leq X \wedge \mathit{meet}(X)) : m_\sigma$$

The meaning constructors for this example combine as shown in (103). The general form of the proof is very close to (101), and in fact the first three steps are exactly the same, since in both examples the non-seed conjunct is *David*. We do not show the details of the combination of the determiner *a* with the noun *professor*; see Chapter 8, Section 8.2 for discussion and illustration of how the meaning constructors for determiners and nouns are combined.

(103) $\mathsf{David} : d_\sigma$

This is the meaning constructor **[David]**. It associates the meaning David with the semantic structure d_σ.

$\lambda x.\lambda Q.\lambda C.\lambda X.C(x \leq X, Q(C, X)) : d_\sigma \multimap [[c \multimap [a_\sigma \multimap cr]] \multimap [c \multimap [a_\sigma \multimap cr]]]$

This is the meaning constructor **[nconj]**. It consumes the resource for the conjunct *David* and produces a modifier of the COORD-RESTR meaning *cr*, which itself depends on the meaning of the conjunction *c* and the meaning of a_σ.

$\lambda Q.\lambda C.\lambda X.C(\mathsf{David} \leq X, Q(C, X)) : [[c \multimap [a_\sigma \multimap cr]] \multimap [c \multimap [a_\sigma \multimap cr]]]$

Combining **[David]** and **[nconj]**, we have this meaning constructor, which we call **[David-conj]**.

$h : [p_\sigma]$

We temporarily introduce the hypothetical meaning *h* corresponding to p_σ for the seed conjunct (see Chapter 8, Section 8.1.4). The glue side of a meaning constructor is marked as a hypothetical premise by square brackets. We must discharge this assumption later in the proof.

$\lambda x.\lambda C.\lambda X.x \leq X : p_\sigma \multimap [c \multimap [a_\sigma \multimap cr]]$

This is the meaning constructor **[nseed1]**. It consumes the meaning resource of the seed conjunct to produce a meaning for the COORD-RESTR meaning *cr* which depends on *c* and a_σ.

$\lambda C.\lambda X.h \leq X : [c \multimap [a_\sigma \multimap cr]]$
Combining the meaning constructors in the previous two steps, we have this meaning constructor, which we call **[h-conj]**.

$\lambda C.\lambda X.C(\mathit{David} \leq X, h \leq X) : c \multimap [a_\sigma \multimap cr]$
Combining **[David-conj]** and **[h-conj]**, we have this meaning constructor, which we call **[David-h-conj]**.

$\wedge : c$ — This is the meaning constructor **[and]**. It provides the meaning $\wedge$ contributed by the conjunction *and*.

$\lambda X.\mathit{David} \leq X \wedge h \leq X : a_\sigma \multimap cr$
Combining **[David-h-conj]** and **[and]**, we have this meaning constructor, which we call **[David-and-h]**.

$\lambda P.\lambda Q.\exists X.P(X) \wedge Q(X) : [a_\sigma \multimap cr] \multimap [a_\sigma \multimap S] \multimap S$
This is the meaning constructor **[nseed2]**.

$\lambda Q.\exists X.\mathit{David} \leq X \wedge h \leq X \wedge Q(X) : [a_\sigma \multimap S] \multimap S$
Combining **[David-and-h]** and **[nseed2]**, we have this meaning constructor, which we call **[David-and-h-quant]**.

$\lambda x.\mathit{meet}(x) : a_\sigma \multimap m_\sigma$ — This is the meaning constructor **[meet]**.

$\exists X.\mathit{David} \leq X \wedge h \leq X \wedge \mathit{meet}(X) : m_\sigma$
Combining **[David-and-h-quant]** and **[meet]**, we have produced a meaning for the sentence containing the hypothesized meaning *h*. We must now discharge this premise, which we introduced earlier.

$\lambda h.\exists X.\mathit{David} \leq X \wedge h \leq X \wedge \mathit{meet}(X) : p_\sigma \multimap m_\sigma$
This is the result of discharging the premise introduced in the fourth step of the proof.

$\lambda S.a(y, \mathit{professor}(y), S(y)) : \forall H.[p_\sigma \multimap H] \multimap H$
This is the meaning constructor **[a-professor]**, the result of combining the meaning constructors for *a* and *professor* (see Chapter 8, Section 8.2).

$a(y, \mathit{professor}(y), \exists X.\mathit{David} \leq X \wedge y \leq X \wedge \mathit{meet}(X)) : m_\sigma$
Combining the meaning constructors in the previous two steps gives us the desired meaning for the sentence.

The meaning deduction for an example such as (96), in which two quantifiers are coordinated, proceeds similarly; we do not provide the proof here.

9. FURTHER READING AND RELATED ISSUES

Besides the seminal work of Bresnan et al. (1985b), Andrews (1983a) contributed early and influential (although unfortunately unpublished) work on coordination in LFG. The 2004 LFG conference hosted a workshop 'Coordination and Agreement', organized by Peter Peterson, at which a number of issues related to the syntax and semantics of coordination were discussed; some of the workshop papers are available online (Butt and King 2004a), including the overview presentation by Peterson (2004b).

Belyaev (2015) explores clausal coordination and subordination constructions in Ossetic, and shows that these phenomena provide a lens on the overall architecture of grammar: the Ossetic data are best explained by appeal to a three-way distinction in grammatical levels, distinguishing c-structure, f-structure, and semantic structure, as assumed in LFG. Belyaev provides a close examination of constructions which are coordinate at c-structure but subordinate at f-structure and semantically, as well as constructions which are coordinate at both c-structure and f-structure but subordinate semantically.

Although coordinate structures are often distinguished by the presence of a conjunction, this is not the only possibility. Brown and Dryer (2008) describe so-called '*and*-verbs' in Walman, which are morphologically verbs but are used to coordinate noun phrases. Lawyer (2010) presents an LFG-based analysis of Walman *and*-verbs and serial verb constructions.

A particularly challenging type of coordinate construction, which Mel'čuk (1988) calls *lexico-semantic coordination*, involves coordination of phrases with different grammatical roles; this construction is attested in Hungarian and Polish, as shown in (104), as well as Russian and other languages. For example, in (104a) the first conjunct in the clause-initial coordinate phrase bears the SUBJ role, and the second conjunct bears the OBJ role.

(104) a. *Ki és mit talált fel?*
who and what invent.PST VM
'Who invented something and what was it?'
(Hungarian: Gazdik 2011, page 43)

b. *Kogo i komu przedstawił?*
who.ACC and who.DAT introduced
'Who did he introduce to whom?'
(Polish: Patejuk 2015, page 80, citing Kallas 1993)

c. *czy* *komukolwiek,* *kiedykolwiek* *i* *do* *czegokolwiek*
PARTICLE anybody.DAT anytime and for anything
przydał się *poradnik*
come in handy guide
'Has a(ny) guide ever come in handy to anybody for anything?'
(Polish: Patejuk 2015, page 80, citing Kallas 1993)

The challenge in the analysis of such structures is to ensure that each conjunct bears the appropriate f-structure role. For in-depth discussion and analysis of lexico-semantic coordination from an LFG perspective, see Gazdik (2011) and Patejuk (2015). Patejuk (2015) goes beyond lexico-semantic coordination to provide a more general discussion and analysis of examples in which the conjuncts differ in some respect, including not only conjuncts with different grammatical functions, but also conjuncts with the same grammatical function but different cases or different c-structure categories; see also Przepiórkowski and Patejuk (2012) and Patejuk and Przepiórkowski (2012).

The relation between apposition and coordination is explored in detail by Sadler and Nordlinger (2006a), who illustrate their discussion with examples from a range of Australian languages. Building on this foundation, Nordlinger and Sadler (2008) and Sadler and Nordlinger (2010) explore the use of sets as an appropriate representation not only of coordinate structures, but also of apposition, generic-specific constructions, inclusory constructions, and other related constructions.

Some early LFG work on coordination is based on syntactic assumptions that have since been abandoned. Kaplan and Maxwell (1988b) proposed a theory of function application in coordination that does not rely on a distinction between distributive and nondistributive features or on the definition presented in (11) for application of a function involving a distributive feature to a set; instead, they propose that the properties of a set are defined as the *generalization* of the properties of its elements (see Chapter 6, Section 9.3 for definition and discussion of generalization). Many of the predictions of the Kaplan and Maxwell (1988b) theory are indistinguishable from the theory presented in this chapter. However, Kaplan and Maxwell's theory makes unwanted predictions involving constraining properties of sets, and also has difficulty in cases where a set has a property that is different from its conjuncts; see Dalrymple and Kaplan (2000) for more discussion.

17

LONG-DISTANCE DEPENDENCIES

Topicalization and left- or right-dislocation constructions, relative clauses, and constituent questions in English and many other languages exemplify *long-distance dependencies*, constructions in which a constituent appears in a position other than the one with which its syntactic function is usually associated. In this sense, it is displaced. For example, in an English topicalization construction like *Chris, David likes*, the initial constituent *Chris* plays two roles: it simultaneously has the status of a displaced phrase (DIS) and is the object of the verb *likes*. Section 1 of this chapter discusses the syntax of long-distance dependencies, showing how the syntactic relation is established between the fronted phrase and its within-clause grammatical function. Section 3 discusses cases in which a long-distance dependency is signaled by special morphological marking: in particular, we discuss and analyze long-distance dependencies in Kikuyu, where sentences with long-distance dependencies exhibit a special tonal change, and in Irish, where the form of complementizers is dependent on the exact type of long-distance dependency involved.

Since many syntactic constraints in long-distance dependency constructions are definable in terms of the grammatical function of the displaced phrase, f-structural constraints on the relation between a displaced constituent and its within-clause functional role will feature heavily in our syntactic discussion. In the earliest LFG work on long-distance dependencies (for example, Kaplan and Bresnan

1982) it was assumed that the relation between a displaced constituent and its corresponding within-clause "gap" was definable in constituent structure terms, using the double arrow notation $\Uparrow$ and $\Downarrow$ to relate the displaced constituent to the "gap". Subsequently, Kaplan and Zaenen (1989b) showed that this treatment made it difficult to account for functional constraints on long-distance dependencies, and the original analysis based on c-structure relations and defined in terms of the $\Uparrow$ and $\Downarrow$ notation was subsequently abandoned; see Dalrymple et al. (1995d) for more discussion of the history of the analysis of long-distance dependencies in LFG. However, even though the primary constraints on long-distance dependencies are formulated in f-structure terms, some LFG analyses assume the existence of *traces*, phonologically null c-structure elements corresponding to the within-clause position of the displaced constituent. In Section 4.2 we discuss evidence for and against traces, with particular attention to the phenomenon of *weak crossover*.

Finally, we turn to a discussion of the semantics of constructions involving long-distance dependencies. Section 6 discusses the semantics of relative clauses and meaning composition, and Section 7 discusses issues that arise in the semantic treatment of constituent questions.

1. SYNTAX OF LONG-DISTANCE DEPENDENCIES

1.1. Topicalization and Dislocation

1.1.1. Topicalization

We begin our discussion of long-distance dependencies with the English topicalization construction, in which a displaced constituent appears at the beginning of the sentence. The term 'topicalization' is something of a misnomer: while the initial constituent can be the topic of the sentence, it is often the case that it has focus status (Prince 1981). We retain the standard term 'topicalization' for this construction, but without the implication that the displaced constituent bears any particular information structure role.

Following early transformational analyses, the displaced constituent is sometimes spoken of as having been "fronted" or "extracted," and we will also use this terminology in our discussion. The fronted phrase also plays a grammatical role within the clause, according to the *Extended Coherence Condition* (Chapter 10, Section 3.3), originally proposed by Zaenen (1980) (see also Fassi-Fehri 1988):

(1) Extended Coherence Condition:

FOCUS and TOPIC must be linked to the semantic predicate argument structure of the sentence in which they occur, either by functionally or by anaphorically binding an argument.

We do not include the features TOPIC and FOCUS at f-structure, instead representing them at the separate level of i-structure (Chapter 10). Rather, we use the overlay function DIS to represent long-distance dependencies in f-structure in this book; see Chapter 2, Section 1.11. We therefore assume a slightly more general version of the Extended Coherence Condition, one which applies to DIS at f-structure as well as to TOPIC and FOCUS, which appear only at i-structure but which must also be related to a grammatical function at f-structure.

In this section, we will examine the syntax of the topicalization construction in English. Examination of this construction reveals c-structural constraints on the permitted constituent structure categories of the fronted constituent as well as f-structural constraints on the path relating the fronted constituent to its within-clause grammatical function. Constraints on the topicalization construction in other languages may differ: as we will see, other languages may allow a different set of phrasal categories to appear in the relevant position or may place different constraints on the f-structural relation between the displaced constituent and its within-clause role.

CATEGORY OF THE DISPLACED PHRASE: The fronted phrase in the English topicalization construction may be one of several phrase structure categories:

(2) a. NP: *<u>Chris</u>, I like.*

b. PP: *<u>To Chris</u>, I gave a book.*

c. AP: *<u>Happy</u>, Chris will never be.*

d. CP: *<u>That Chris was a movie star</u>, I never would have guessed.*

e. VP: ?*<u>To leave</u>, we convinced Chris.* (acceptable for some speakers; see Chapter 15, Section 3.2)

The sentences in (2) exemplify the permitted range of phrase structure categories in this construction:

(3) Phrasal category of displaced phrases in the English topicalization construction: NP, PP, AP, CP, VP

GRAMMATICAL FUNCTION OF THE DISPLACED PHRASE: The within-clause grammatical function of the fronted phrase is also constrained: some functions can be related to the displaced phrase, whereas others cannot. For instance, the fronted constituent can fill the role of OBJ:

(4) *Chris, we like.*

$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{like}\langle\textsc{subj},\textsc{obj}\rangle\text{’} \\ \textsc{dis} & \left\{ \begin{bmatrix} \textsc{pred} & \text{‘Chris’} \end{bmatrix} \right\} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{pro}\text{’} \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 1 \\ \textsc{num} & \textsc{pl} \end{bmatrix} \end{bmatrix} \\ \textsc{obj} & \end{bmatrix}$$

In this sentence, *Chris* is the OBJ of the verb *like*, but this phrase is displaced: it does not appear in the usual immediately postverbal position associated with objects in English. The f-structure for *Chris* is a member of the DIS set, and there is also a *path* through the f-structure defining its within-clause grammatical function; in (4), the path is OBJ. In (5), the displaced phrase is the OBJ of the subordinate COMP, so that the path leading to the within-clause function of the displaced phrase is COMP OBJ:

(5) *Chris, we think that David saw.*

$$\begin{bmatrix} \textsc{pred} & \text{‘}\textsc{think}\langle\textsc{subj},\textsc{comp}\rangle\text{’} \\ \textsc{dis} & \left\{ \begin{bmatrix} \textsc{pred} & \text{‘Chris’} \end{bmatrix} \right\} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{pro}\text{’} \\ \textsc{index} & \begin{bmatrix} \textsc{pers} & 1 \\ \textsc{num} & \textsc{pl} \end{bmatrix} \end{bmatrix} \\ \textsc{comp} & \begin{bmatrix} \textsc{pred} & \text{‘}\textsc{see}\langle\textsc{subj},\textsc{obj}\rangle\text{’} \\ \textsc{compform} & \textsc{that} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{‘David’} \end{bmatrix} \\ \textsc{obj} & \end{bmatrix} \end{bmatrix}$$

Not all within-clause functions can be related to a member of the DIS set, however. As discussed in Chapter 6, Section 6, for some speakers it is possible for a displaced phrase to be related to a position within the COMP of a so-called "bridge verb" like *think*, but not to a position within the COMP of a nonbridge verb like *whisper*. The distinction between bridge and nonbridge verbs is not reflected in the grammatical function of the clausal complement: in both cases, the path to the within-clause argument is COMP OBJ. Instead, this requirement is stated as an additional condition on the f-structures in the extraction domain which applies in the case of those speakers who identify a difference in grammaticality that is related to the bridge/nonbridge verb distinction.

Where bridge and nonbridge verbs are judged to be distinct in this respect, we use the f-structure attribute LDD (for "long-distance dependency") to distinguish between the two. The value $-$ for the feature LDD is lexically specified by a nonbridge verb like *whisper* as appearing in its COMP. Such f-structures cannot participate in a long-distance dependency. This captures the unacceptability of (6) for the relevant set of speakers, since the COMP f-structure contains the attribute-value pair $\langle$LDD, $-\rangle$:

(6) * *Chris, we whispered that David saw.*

F-structure violating Bridge Verb Constraint:

$$\left[\begin{array}{ll}
\text{DIS} & \left\{ \left[\text{PRED} \quad \text{`CHRIS'} \right] \right\} \\
\text{PRED} & \text{`WHISPER}\langle\text{SUBJ,COMP}\rangle\text{'} \\
\text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{INDEX} & \left[\begin{array}{ll} \text{PERS} & 1 \\ \text{NUM} & \text{PL} \end{array}\right] \end{array}\right] \\
\text{COMP} & \left[\begin{array}{ll} \text{PRED} & \text{`SEE}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{COMPFORM} & \text{THAT} \\ \text{LDD} & - \\ \text{SUBJ} & \left[ \text{PRED} \quad \text{`DAVID'} \right] \\ \text{OBJ} & \end{array}\right]
\end{array}\right]$$

In (6), the path relating the f-structure for *Chris* to its within-clause function goes through the COMP f-structure of the verb *whisper*, which has the value $-$ for the attribute LDD; this is disallowed. We demonstrate later in this section how, for the relevant dialects, this constraint can be captured in formal terms.

A number of other constraints on long-distance dependencies were originally explored by Ross (1967) and have since been the subject of intense scrutiny and debate. Ross identified a number of constraints involving 'islands': areas of a sentence from which extraction of an element to form a long-distance dependency is prohibited. Among these constraints is the Sentential Subject Constraint, according to which a long-distance dependency cannot involve a position inside a sentential subject — that is, subjects are islands for extraction:

(7) **Chris, [that David saw ___] surprised me.*
(cf. *That David saw Chris surprised me.*)

F-structure violating Sentential Subject Constraint:

$$\left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{surprise}\langle\textsc{subj},\textsc{obj}\rangle\text{’} \\
\textsc{dis} & \left\{\left[\begin{array}{ll}\textsc{pred} & \text{‘Chris’}\end{array}\right]\right\} \\
\textsc{subj} & \left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{saw}\langle\textsc{subj}\rangle\text{’} \\
\textsc{compform} & \textsc{that} \\
\textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{‘David’}\end{array}\right] \\
\textsc{obj} &
\end{array}\right] \\
\textsc{obj} & \left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{pro}\text{’} \\
\textsc{index} & \left[\begin{array}{ll}\textsc{pers} & 1 \\ \textsc{num} & \textsc{pl}\end{array}\right]
\end{array}\right]
\end{array}\right]$$

This constraint is simply stated: the path to the within-clause function of DIS may not include SUBJ. Other constraints on long-distance dependencies can be characterized similarly, either as constraints on grammatical functions permitted on the path or as constraints on attributes and values in f-structures through which the path passes.

There is little consensus on the proper characterization of long-distance dependencies involving modifying adjuncts. The situation appears to be similar to the one we have reported for bridge and nonbridge verbs when it comes to variability in speakers' judgements. For example, Williams (1992, page 307) claims that examples like (8), which involve a relation between an initial question phrase and a position inside an adverbial modifier, are "marginal though possible":

(8) *?Who did John go to New York [after talking to]?*

However, Cinque (1990) and Hornstein and Weinberg (1995) count as ungrammatical examples that are very similar to (8):

(9) a. **To whom did you leave [without speaking]?*
b. **What did John drink cognac [after singing]?*

Constraints on long-distance dependencies involving modifying adjuncts are difficult to characterize and judgements, as we have stated, vary. However, we believe that some basic conclusions can be drawn. First, some dependencies involving modifying adjuncts are generally acceptable:

(10) *This room, Julius teaches his class in.*

$$
\left[\begin{array}{ll}
\text{DIS} & \left\{\left[\begin{array}{ll} \text{PRED} & \text{`ROOM'} \\ \text{DEF} & + \\ \text{DEIXIS} & \text{PROX} \\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3 \\ \text{NUM} & \text{SG}\end{array}\right]\end{array}\right]\right\} \\
\text{PRED} & \text{`TEACH}\langle\text{SUBJ,OBJ}\rangle\text{'} \\
\text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`JULIUS'}\end{array}\right] \\
\text{OBJ} & \left[\begin{array}{ll}
\text{PRED} & \text{`CLASS'} \\
\text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3 \\ \text{NUM} & \text{SG}\end{array}\right] \\
\text{POSS} & \left[\begin{array}{ll}
\text{PRED} & \text{`PRO'} \\
\text{PRONTYPE} & \text{PERS} \\
\text{CONCORD} & \left[\begin{array}{ll}\text{CASE} & \text{GEN}\end{array}\right] \\
\text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{GEND} & \text{M}\end{array}\right]
\end{array}\right] \\
\text{ADJ} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{`IN}\langle\text{OBJ}\rangle\text{'} \\ \text{OBJ} & \end{array}\right]\right\}
\end{array}\right]
\end{array}\right]
$$

Other examples involving a dependency between a member of the DIS set and a position inside an ADJ are not acceptable. For example, the unacceptability of (11) shows that extraction from a tensed sentential modifier is not permitted:

(11) **Chris, we think that David laughed after we selected.*
(cf. *We think that David laughed after we selected Chris.*)

F-structure violating Tensed Adjunct Constraint:

$$
\left[\begin{array}{ll}
\text{PRED} & \text{`THINK}\langle\text{SUBJ,COMP}\rangle\text{'} \\
\text{DIS} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{`Chris'}\end{array}\right]\right\} \\
\text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`PRO'} \\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 1 \\ \text{NUM} & \text{PL}\end{array}\right]\end{array}\right] \\
\text{COMP} & \left[\begin{array}{ll}
\text{PRED} & \text{`LAUGH}\langle\text{SUBJ}\rangle\text{'} \\
\text{COMPFORM} & \text{THAT} \\
\text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`David'}\end{array}\right] \\
\text{ADJ} & \left\{\left[\begin{array}{ll}
\text{PRED} & \text{`SELECT}\langle\text{SUBJ,OBJ}\rangle\text{'} \\
\text{COMPFORM} & \text{AFTER} \\
\text{TENSE} & \text{PST} \\
\text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`PRO'} \\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 1 \\ \text{NUM} & \text{PL}\end{array}\right]\end{array}\right] \\
\text{OBJ} &
\end{array}\right]\right\}
\end{array}\right]
\end{array}\right]
$$

We propose the following general characterization of the possible within-clause grammatical roles of the displaced phrase in the English topicalization construction, which takes into account relevant island constraints:

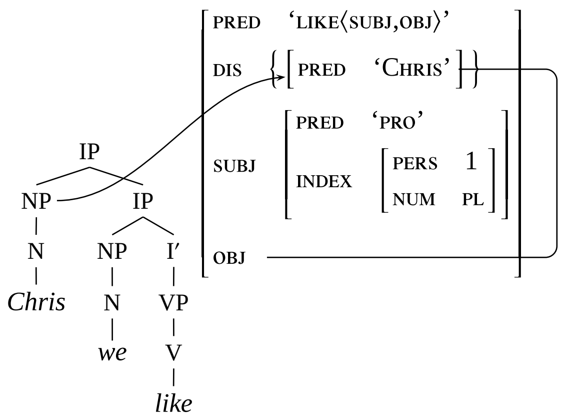
(12) In the English topicalization construction, the displaced phrase can be related to a grammatical function that is embedded inside any number of XCOMP, COMP (for some speakers, the COMP function must be governed by a bridge verb), or tensed sentential OBJ functions, or to a grammatical function inside a possibly embedded nontensed ADJ function.

Other languages place different constraints on the topicalization path. For example, Kroeger (1993, Chapter 7) shows that in Tagalog, the topicalization path must consist exclusively of subjects: only a SUBJ may be extracted, and the only function out of which extraction is permitted is SUBJ. This is true not only for the topicalization construction but also for other long-distance dependencies in Tagalog; the path in the constituent question construction and the relative clause construction must also contain only SUBJ attributes.

CONSTITUENT STRUCTURE AND FUNCTIONAL CONSTRAINTS: In Chapter 4, Section 2.3.2, we discussed the relation between constituent structure specifier positions and discourse functions: in many languages, specifier positions must be occupied by phrases bearing the discourse functions topic or focus. King (1995) analyzes the configurational encoding of topic and focus in Russian, showing that the Russian topic appears in the specifier position of IP, and Kroeger (1993) shows that the same is true in Tagalog.

Interestingly, however, in English a fronted (DIS) phrase which can bear the discourse function topic does not appear in specifier position. Bresnan et al. (2016, Chapter 9) show that such phrases are adjoined to IP in English:

(13) *Chris, we like.*



To analyze examples like (13), we propose this phrase structure rule:

(14) $$\text{IP} \longrightarrow \begin{pmatrix} \text{TpczP} \\ \downarrow \in (\uparrow \text{DIS}) \\ (\uparrow \text{TpczPath}) = \downarrow \end{pmatrix} \begin{pmatrix} \text{IP} \\ \uparrow = \downarrow \end{pmatrix}$$

Here we use the *constituent structure metacategory abbreviation* TpczP for the phrase structure category of the fronted phrase, where Tpcz stands for topicalization; the role of metacategories in syntactic description is discussed in Chapter 5, Section 1.3. We also use the functional abbreviation TpczPath for the path through the f-structure to the within-clause function of the fronted phrase.

The set of phrasal categories that can participate in the topicalization construction in English is given in (3) of this chapter. On this basis, we define TpczP for English in rule (14) as the following disjunction of categories:

(15) TpczP [English] ≡ {NP | PP | VP | AP | CP}

We must also properly constrain the path through the f-structure that defines the within-clause grammatical function of the displaced phrase. Formally, this relation involves *functional uncertainty*, discussed in Chapter 6, Section 1.2. In (12) above, a set of constraints on the long-distance path for topicalization in English were outlined. We can formally characterize these constraints as follows.

We start with the Sentential Subject constraint, defined as SSC in (7):

(16) Sentential Subject Constraint

$$\text{SSC} \equiv [\textsc{gf} - \textsc{subj}]^*\ \textsc{gf}$$

The initial portion of the path defined in (16) may not include SUBJ,[1] though it may end in SUBJ or any other grammatical function GF. The possibility for deep embedding is represented by the *Kleene star operator* * permitting any number of attributes defined as members of the metacategory GF other than SUBJ on the path.

The Bridge Verb Constraint, which seems to apply for a subset of speakers, is captured via the expression defined as BVC in (17). The definition relies on an off-path constraint referring to an attribute of the f-structures on the path, $(\rightarrow \textsc{ldd}) \neq -$, rather than their grammatical function:

(17) Bridge Verb Constraint

$$\text{BVC} \equiv \underset{(\rightarrow \textsc{ldd}) \neq -}{\textsc{gf}^*}\quad \textsc{gf}$$

Recall the use of symbols like $\rightarrow$ in off-path constraints, discussed in (97) of Chapter 6, Section 6: the symbol $\rightarrow$ in an off-path constraint on an attribute refers to the f-structure that is the value of the attribute.

(18) In an expression like $\underset{(\rightarrow s)}{a}$, $\rightarrow$ refers to the value of the attribute a.

Thus, in (17), the off-path constraint permits any path relating the displaced phrase to its within-clause grammatical function, as long as it does not pass through an f-structure bearing the attribute LDD with value $-$.

Finally, according to the Tensed Adjunct Constraint, the path defining the within-clause grammatical function of a displaced phrase may include a non-tensed ADJ function, but not a tensed ADJ. The following definition of the path TAC accomplishes this:[2]

(19) Tensed Adjunct Constraint

$$\text{TAC} \equiv \neg[\textsc{gf}^*\ \textsc{adj}\ \underset{(\rightarrow \textsc{tense})}{\in}\ \textsc{gf}^*]$$

The off-path constraint $(\rightarrow \textsc{tense})$ requires a member of the ADJ set to contain the attribute TENSE. Thus, the path within the square brackets ($[\textsc{gf}^*\ \textsc{adj}\ \underset{(\rightarrow \textsc{tense})}{\in}\ \textsc{gf}^*]$) picks out all paths which pass through a tensed adjunct. The complement operator for regular expressions, written as $\neg$, picks out all paths which do not obey these constraints: in other words, paths which do *not* go through a tensed adjunct

[1] The relative-difference operator for regular expressions, written as a minus sign ($-$), is defined and discussed in Chapter 6, Section 1. The expression $\textsc{gf} - \textsc{subj}$ represents any grammatical function (GF) except SUBJ, and $[\textsc{gf} - \textsc{subj}]^*$ represents any sequence of grammatical functions that does not contain SUBJ.

[2] In Chapter 6, Section 3.1, we discussed the use of expressions in which the set membership symbol $\in$ is used as an attribute to allow reference to some member of a set.

(see Chapter 6, Section 1 for discussion of regular expressions and complementation).

Together, the constraints in (16), (17), and (19) express restrictions which apply to the path through f-structure that defines the within-clause grammatical function of the displaced phrase. Putting these three constraints together via intersection (Chapter 6, Section 1), we are able to define TᴘᴄᴢPᴀᴛʜ thus:

(20) TᴘᴄᴢPᴀᴛʜ [English] ≡ SSC & BVC & TAC

TᴘᴄᴢPᴀᴛʜ is therefore restricted by a set of off-path constraints in addition to constraints on the grammatical functions that can appear on the path between filler and gap. The within-clause grammatical function of the displaced phrase is permitted to be arbitrarily deeply embedded inside any number of properly constrained xᴄᴏᴍᴘ, ᴄᴏᴍᴘ, or ᴏʙᴊ functions, and optionally to appear within a nontensed member of an ᴀᴅᴊ set.

As noted earlier, different languages impose different constraints on the paths involved in long-distance dependencies: Kroeger (1993, Chapter 7) shows that only subjects can participate in long-distance dependencies (LDDs) in Tagalog:

(21) TᴘᴄᴢPᴀᴛʜ [Tagalog] ≡ $\textsc{subj}^{+}$

This expression uses the *Kleene plus* operator + to indicate that the relevant path in Tagalog consists of at least one occurrence of sᴜʙᴊ: only a sᴜʙᴊ may be involved in establishing a long-distance dependency, and only a sᴜʙᴊ may contain a displaced phrase. LFG research has not yet established a complete typology of possible paths in long-distance dependencies: future research will no doubt reveal more about the possible range of crosslinguistic and cross-constructional variation in long-distance paths, as well as universal generalizations concerning constraints on long-distance paths.

Tᴏᴘɪᴄᴀʟɪᴢᴀᴛɪᴏɴ ɪɴ ᴄᴏᴏʀᴅɪɴᴀᴛᴇ sᴛʀᴜᴄᴛᴜʀᴇs: It has long been noted that coordinate structures obey the *across-the-board constraint* (Ross 1967; Williams 1990), according to which a topicalized phrase bears a grammatical function inside one conjunct of a coordinate structure only if it also bears a grammatical function inside the other conjuncts. Example (22) is ungrammatical because the topicalized phrase *David* bears the ᴏʙᴊ function only in the first conjunct of the coordinate sentence:

(22) **David, [Chris hates ___ and Matty likes Ursula].*

The across-the-board constraint requires the topicalized phrase to bear a grammatical function "across the board", that is, within each conjunct in a coordinate construction:

(23) *David, [Chris hates ___ and Matty likes ___].*

$$\left[\begin{array}{ll}
\textsc{conj} & \textsc{and} \\
 & \left\{\begin{array}{l}
\left[\begin{array}{ll}
\textsc{dis} & \left\{\left[\textsc{pred}\ \ \text{‘David’}\right]\right\} \\
\textsc{pred} & \text{‘}\textsc{hate}\langle\textsc{subj},\textsc{obj}\rangle\text{’} \\
\textsc{subj} & \left[\textsc{pred}\ \ \text{‘Chris’}\right] \\
\textsc{obj} &
\end{array}\right] \\
\left[\begin{array}{ll}
\textsc{dis} & \left\{\ \right\} \\
\textsc{pred} & \text{‘}\textsc{like}\langle\textsc{subj},\textsc{obj}\rangle\text{’} \\
\textsc{subj} & \left[\textsc{pred}\ \ \text{‘Matty’}\right] \\
\textsc{obj} &
\end{array}\right]
\end{array}\right\}
\end{array}\right]$$

In (23), the topicalized phrase is the OBJ of both *hates* and *likes*. The across-the-board constraint falls out as a consequence of our theory of coordination and long-distance dependencies. Since grammatical functions are *distributive features* (Chapter 6, Section 3.2), asserting that an f-structure is the OBJ of a set means that it is the OBJ of each member of the set. That is, resolving the path to the within-clause grammatical function of the topic correctly entails that the topicalized phrase must bear a grammatical function within each conjunct of the coordinate phrase.

Kaplan and Maxwell (1988b) discuss examples like (24), in which the topicalized phrase *David* is the OBJ of the first conjunct and the $\textsc{obj}_{\textsc{theme}}$ of the second conjunct:

(24) *This book, [David bought and Chris gave Matty].*

$$\left[\begin{array}{ll} \text{CONJ} & \text{AND} \\ & \left\{\begin{array}{l} \left[\begin{array}{ll} \text{DIS} & \left\{\left[\begin{array}{ll} \text{PRED} & \text{`BOOK'} \\ \text{DEF} & + \\ \text{DEIXIS} & \text{PROX} \\ \text{INDEX} & \left[\begin{array}{ll} \text{PERS} & 3 \\ \text{NUM} & \text{SG} \end{array}\right] \end{array}\right]\right\} \\ \text{PRED} & \text{`BUY}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`David'} \end{array}\right] \\ \text{OBJ} & \text{———} \end{array}\right] \\ \\ \left[\begin{array}{ll} \text{DIS} & \{\,\text{—}\,\} \\ \text{PRED} & \text{`GIVE}\langle\text{SUBJ,OBJ,OBJ}_{\text{THEME}}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`Chris'} \end{array}\right] \\ \text{OBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`Matty'} \end{array}\right] \\ \text{OBJ}_{\text{THEME}} & \text{———} \end{array}\right] \end{array}\right\} \end{array}\right]$$

These examples show that the fronted phrase can bear different grammatical functions within each conjunct.[3] To analyze these examples, Kaplan and Maxwell (1988b) provide the definition of functional uncertainty given in (27) of Chapter 6, Section 1.2 (page 225), repeated here:

(25) Functional uncertainty:

If η is a regular expression, then $(f\ \eta) = v$ holds if and only if

$$(f\ a\ \text{SUFF}(a, \eta)) = v$$

for some symbol a, where $\text{SUFF}(a, \eta)$ is the set of suffix strings s such that $as\ \in \eta$.

The effect of this definition is to allow a regular expression representing a path through the f-structure to be resolved differently in each conjunct of a coordinate structure. When a long-distance dependency involves positions inside a set

[3] Kaplan and Zaenen (1989b) discuss constraints on the long-distance path in coordinate structures in Japanese, based on work by Saiki (1985): the grammatical function of the fronted constituent must either be SUBJ in all conjuncts, or a nonsubject function in all conjuncts. Similar constraints hold in English:

(a) **Who did Chris think [David met ___] and [___ saw Matty]?*

Kaplan and Zaenen show how the relevant path can be defined so as to predict these facts. Falk (2000) also discusses these patterns and provides an alternative analysis.

representing a coordinate structure, the definition in (25) allows the as yet unexplored suffix of the regular expression representing the path to be expanded independently within each element of the set, as is required in the analysis of (24).

1.1.2. Left and Right Dislocation

Another type of displacement is dislocation. Dislocation constructions differ from topicalization constructions in having a coreferential pronoun rather than a gap. This means that without the dislocated constituent, the clause would still be grammatical — it is syntactically and semantically complete in its own right. Dislocation can be to the right or left of the clause, though the information structure roles associated with these syntactic positions are distinct. The following English examples illustrate left dislocation used to introduce a topic and right dislocation with a clarifying function, respectively.

(26) Q: *What's the matter?*

A: *[This little girl]$_i$, she$_i$'s lost her$_i$ parents. She doesn't know where they are.*

(27) *They$_i$ filed a complaint last Friday, [Karen and Dave]$_i$.*

Whether leftwards or rightwards, dislocation involves an anaphoric dependency between the dislocated constituent, which is a member of the DIS set at f-structure, and a within-clause grammatical function.

In at least some dialects of British English, pronouns can be right dislocated, as illustrated in (28).[4] These right-dislocated pronouns (ProTags; Mycock 2017) bear default accusative case (on which, see Hristov 2013b) and therefore case mismatch regularly occurs. Thus an anaphoric control analysis is justified.

(28) a. *I$_i$ love sushi, me$_i$.*

b. *I can never remember his$_i$ name, him$_i$.*

c. *They$_i$'re good, them$_i$.*

Of course, at f-structure the direction of the dislocation is not specified. (29) provides an analysis of a sentence involving both left and right dislocation in a dialect of English that permits personal ProTags; the f-structures of both dislocated phrases appear as members of the DIS set.

[4] Unlike right-dislocated full noun phrases, ProTags do not have a clarifying function. See Mycock (2017) for details.

(29) *Mary*$_i$, *I*$_j$ *saw her*$_i$ *yesterday, me*$_j$.

$$\begin{bmatrix}
\text{PRED} & \text{`SEE}\langle\text{SUBJ,OBJ}\rangle\text{'} \\
\text{DIS} & \left\{ \begin{matrix} \begin{bmatrix}\text{PRED} & \text{`MARY'}\end{bmatrix} \\ \begin{bmatrix} \text{PRED} & \text{`PRO'} \\ \text{CONCORD} & \begin{bmatrix}\text{CASE} & \text{ACC}\end{bmatrix} \\ \text{INDEX} & \begin{bmatrix}\text{PERS} & 1 \\ \text{NUM} & \text{SG}\end{bmatrix}\end{bmatrix}\end{matrix}\right\} \\
\text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`PRO'} \\ \text{CONCORD} & \begin{bmatrix}\text{CASE} & \text{NOM}\end{bmatrix} \\ \text{INDEX} & \begin{bmatrix}\text{PERS} & 1 \\ \text{NUM} & \text{SG}\end{bmatrix}\end{bmatrix} \\
\text{OBJ} & \begin{bmatrix} \text{PRED} & \text{`PRO'} \\ \text{CONCORD} & \begin{bmatrix}\text{CASE} & \text{ACC}\end{bmatrix} \\ \text{INDEX} & \begin{bmatrix}\text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{GEND} & \text{F}\end{bmatrix}\end{bmatrix} \\
\text{ADJ} & \left\{ \begin{bmatrix}\text{PRED} & \text{`YESTERDAY'}\end{bmatrix} \right\}
\end{bmatrix}$$

How are different types of dislocation distinguished then, if not at f-structure? As mentioned previously, the information structure roles of dislocations differ depending on which clausal periphery — left or right — they occupy. This is an issue which has not received much attention in LFG work (though see Berman 2003, Szűcs 2014), but it is clear that relevant syntactic positions at the level of c-structure can be annotated with the necessary information to capture the differences in question (similar to the way in which discourse configurationality is analyzed in LFG; see Chapter 10, Section 4.4.3). This possibility remains to be fully explored.

1.2. Relative Clauses

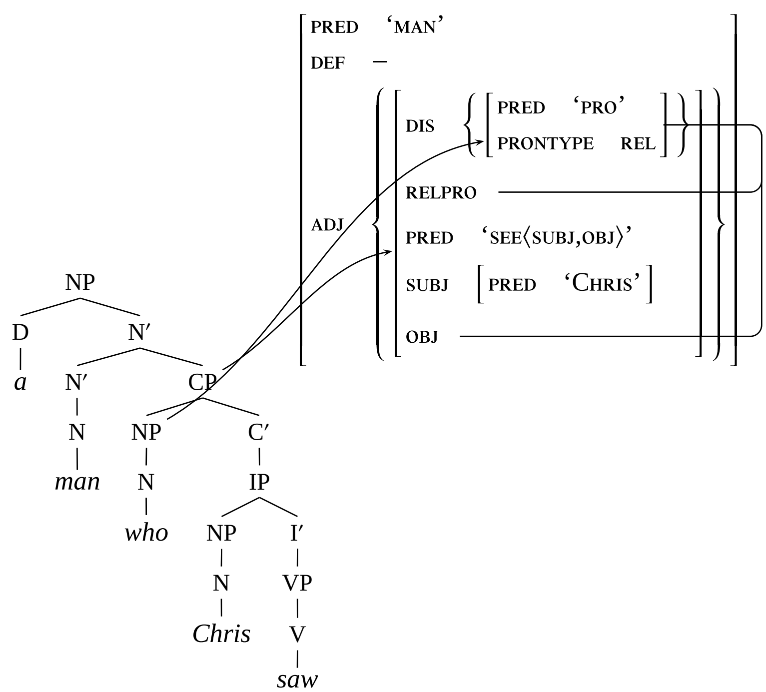
Relative clauses in English and many other languages also involve long-distance dependencies. Unlike the situation with topicalization, two long-distance dependencies are involved in a relative clause construction.

The first dependency holds between the fronted phrase and the within-clause grammatical function it fills. In early LFG work, Bresnan and Mchombo (1987) propose that the fronted phrase in a relative clause bears the syntacticized TOPIC function. By the Extended Coherence Condition, given in (1), the TOPIC must be linked to a grammatical function within the clause. As discussed in Chapter 2, Section 1.11 (see also Chapter 4, Section 2.3), we do not adopt this approach, but use instead the overlay function DIS in the analysis of long-distance dependencies and instances of dislocation. As an overlay function, members of the DIS set must be integrated into the structure of a clause via an association with a primary, nonoverlay function, consistent with the basic principle underlying the Extended Coherence Condition.

The second dependency involves the relative pronoun and its position, possibly embedded, within the fronted phrase. We follow Kaplan and Bresnan (1982) in representing this syntactic dependency at f-structure; the f-structure of the relative pronoun appears as the value of the attribute RELPRO within the relative clause. Similar representations have also been adopted by Butt et al. (1999) and Falk (2001b).

The c-structure and f-structure for the phrase *a man who Chris saw* are:

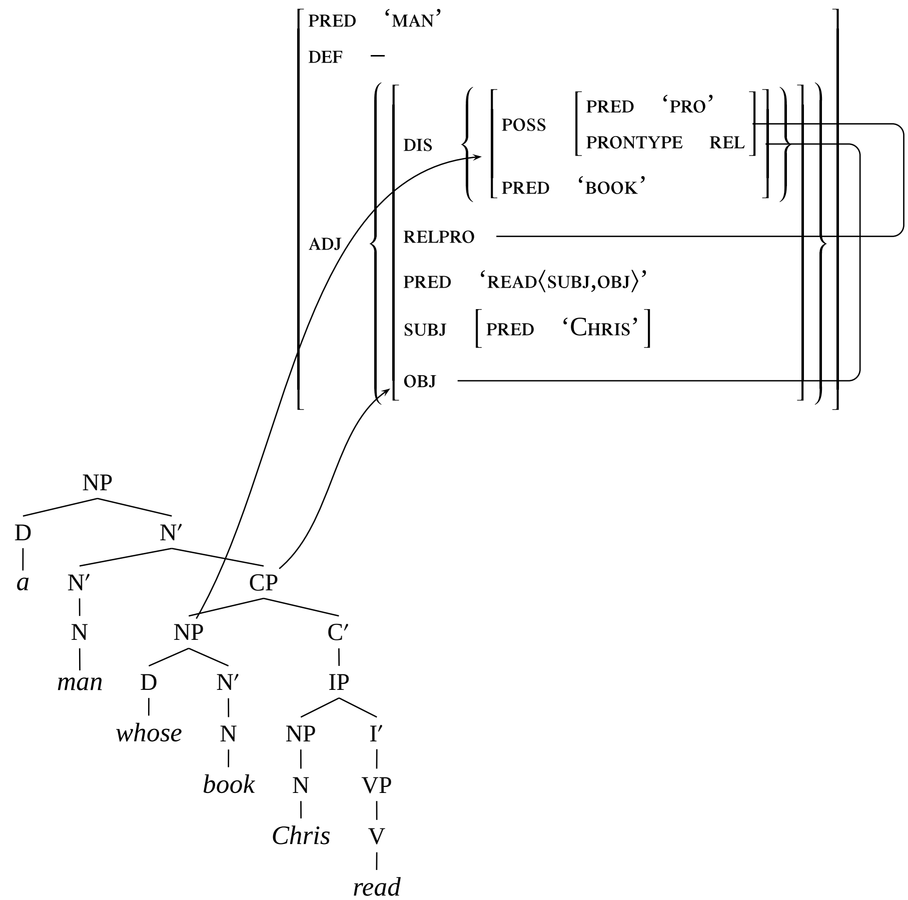
(30) *a man who Chris saw*



In (30), the relative pronoun appears in initial position in the relative clause, and its f-structure is both a member of the set that is the value of DIS and the RELPRO of the relative clause.

Example (31) shows that the relative pronoun can also appear as a subconstituent of the initial phrase. Here the relative pronoun *whose* is a subconstituent of the fronted phrase *whose book*:

(31) *a man whose book Chris read*



In (31), the value of the DIS attribute is a set with one member, f-structure of the fronted phrase *whose book*, and the value of the RELPRO attribute is the f-structure of the relative pronoun *whose*. We examine syntactic constraints on both of these dependencies below.

We propose the following phrase structure rules for the analysis of these examples:

(32)
$$\text{N}' \longrightarrow \begin{pmatrix}\text{N}'\\ \uparrow=\downarrow\end{pmatrix} \quad \begin{array}{c}\text{CP}^*\\ \downarrow\in(\uparrow\ \textsc{adj})\end{array}$$

(33)
$$\text{CP} \longrightarrow \begin{pmatrix}\text{RelP}\\ \downarrow\in(\uparrow\ \textsc{dis})\\ (\uparrow\ \text{RTopicPath}) = \downarrow\\ (\uparrow\ \textsc{relpro}) = (\downarrow\ \text{RelPath})\\ (\uparrow\ \textsc{relpro prontype}) =_c \textsc{rel}\end{pmatrix} \quad \begin{pmatrix}\text{C}'\\ \uparrow=\downarrow\end{pmatrix}$$

The first two annotations on the RelP daughter in (33) are similar to the annotations on the rule for English topicalization constructions in (14). The constraint $\downarrow \in (\uparrow$ DIS) requires the f-structure corresponding to the RelP node to fill the DIS role in the f-structure. The constraint ($\uparrow$ RTopicPath)=$\downarrow$ ensures that the f-structure of the initial phrase also fills a grammatical function within the clause, constrained by the long-distance path RTopicPath; we define RTopicPath below.

The third and fourth annotations constrain the value of the RELPRO attribute in the relative clause f-structure. The constraint in the third line, ($\uparrow$ RELPRO) = ($\downarrow$ RelPath), requires the RELPRO f-structure to appear at the end of the path RelPath within the f-structure of the RelP. Below, we provide a definition of RelPath that properly constrains the role of the relative pronoun within the fronted phrase. Finally, the constraint ($\uparrow$ RELPRO PRONTYPE) $=_c$ REL is a constraining equation (Chapter 5, Section 2.8) requiring the value of the RELPRO attribute to have a PRONTYPE attribute with value REL: the value of the RELPRO attribute must be a relative pronoun.

1.2.1. Category of the Displaced Phrase

The constituent structure metacategory RelP in (33) represents the phrase structure categories that can appear in initial position in a CP relative clause. The phrases in (34) exemplify the possible instantiations of RelP in English.[5]

(34) a. NP: *a man <u>who</u> I selected*

b. PP: *a man <u>to whom</u> I gave a book*

c. AP: *the kind of person <u>proud of whom</u> I could never be*

d. AdvP: *the city <u>where</u> I live*

Therefore, we define RelP for English in the rule in (33) as the following disjunction of categories:

(35) RelP [English] ≡ {NP | PP | AP | AdvP}

1.2.2. Grammatical Function of the Displaced Phrase

Next, we define RTopicPath, the path relating the fronted constituent in a relative clause to its within-clause grammatical function. Constraints on RTopicPath are very similar to the constraints on TpczPath discussed in Section 1, as the following examples show:

(36) a. *Chris, we like.*

b. *a man who we like*

(37) a. *Chris, we think that David saw.*

b. *a man who you think that David saw*

[5] Example (34c) is due to Webelhuth (1992).

(38) Bridge Verb Constraint violation (ungrammatical for some but not all speakers)

a. **Chris, we whispered that David saw.*

b. **a man who you whispered that David saw*

(39) Sentential Subject Constraint violation

a. **Chris, [that David saw ___] surprised me.*

b. **a man who [that David saw ___] surprised me*

(40) Tensed Adjunct Constraint violation

a. **Chris, we think that David laughed when we selected.*

b. **a man who we think that David laughed when we selected*

We therefore propose that the same constraints restrict both the English RTopicPath and the long-distance path in topicalization constructions. The expressions in (20) and (41) are exactly the same:

(41) RTopicPath [English] ≡ SSC & BVC & TAC

Examination of other languages reveals different constraints on RTopicPath. As noted earlier, Kroeger (1993, Chapter 7) shows that in Tagalog, RTopicPath is SUBJ^+, that is, paths consisting only of SUBJ. Saiki (1985) discusses the definition of RTopicPath in Japanese, exploring constraints on RTopicPath in the causative and passive constructions.

1.2.3. Grammatical Function of the Relative Pronoun

The definition of RelPath must appropriately constrain the grammatical function of the relative pronoun within the fronted DIS f-structure. As originally noted by Ross (1967) and explored in detail by Bresnan (1976), Webelhuth (1992), Falk (2001b), and many others, the relative pronoun may be embedded inside the fronted phrase. Ross (1967) provides this example of a deeply embedded relative pronoun:

(42) *[Reports [[the height of the lettering on the cover of which] the government prescribes ___]] should be abolished.*

Ross (1967) originally used the term *pied piping* in the transformational analysis of these constructions: in moving to the front of the sentence, the relative pronoun lures some additional material along with it, like the Pied Piper of Hamelin lured rats and children along with him as he left Hamelin.

Research on pied piping has revealed a range of constraints on the long-distance path RelPath to the relative pronoun in the fronted phrase:

(43) a. *the man [who] I met*

b. *the man [whose book] I read*

c. *the man [whose brother's book] I read*

d. *the report [the cover of which] I designed*

e. *the man [faster than whom] I can run*

f. *the kind of person [proud of whom] I could never be*

g. *the report [the height of the lettering on the cover of which] the government prescribes*

h. **the man [a friend of whose brother] I met*

i. *the room [in which] I teach*

j. **the man [the woman next to whom] I met*

In all of these examples, the phrase structure category of the fronted phrase is one of the categories defined by RelP, and no constraints on RTopicPath are violated. Example (43a) shows that the relative pronoun can itself appear in fronted position; in such a case, RelPath is the empty path. Examples (43b–c) indicate that the relative pronoun can appear as a possessor phrase, filling the poss role in the dis f-structure, or as the possessor of a possessor. It can also appear as the object of an oblique argument, as in (43d–f), or embedded inside an oblique argument, as in (43g), though it may not fill the poss role inside an oblique phrase (43h).[6] It can appear as the object of a fronted adjunct phrase (43i), though it may not appear as an adjunct inside the fronted phrase (43f).

Given these facts, we propose the following definition of RelPath in English:

(44) English RelPath:

$\{\text{POSS}^* \mid [(\text{OBL}_\theta)\ \text{OBJ}]^*\}$

In other languages the definition of RelPath differs. Webelhuth (1992) provides a thorough discussion of pied piping in Germanic, showing that constraints on pied piping in English relative clauses are different from the constraints that hold in German, Dutch, Swedish, and other Germanic languages.

1.2.4. An Alternative 'Nonmediated' Analysis of Relative Clauses

The standard LFG analysis presented so far assumes that there is a semantic relation between the relative pronoun and the modified head noun, to be explored in Section 6.1, but that the modified head noun in the matrix clause does not bear a syntactic relation within the relative clause. Falk (2010) refers to this as the anaphorically mediated (or simply 'mediated') analysis of relative clauses, since the syntactic relation between the head noun and the relative clause is not direct, but is mediated by the relative pronoun. He goes on to observe that under such an analysis it is unexpected to find relative clauses, such as (45b), which do not contain a relative pronoun.

[6] Louisa Sadler (p.c.) points out that this may not be true for all speakers given that some judge constructions such as *the man a friend of whose brother I met* to be acceptable.

(45) a. *the man who Chris saw*

b. *the man (that) Chris saw*

For examples like (45b), Falk states that a direct, anaphorically unmediated analysis of the relative clause construction would be more appropriate, and then goes on to argue that relative clauses that include relative pronouns should also be analyzed in this way. Relative clause constructions lacking relative pronouns, such as the one in (45b), are not restricted to English, but in fact are more common crosslinguistically according to Falk.

Falk also considers other types of relative clause constructions that provide support for adopting an unmediated analysis more generally. In a head-internal relative clause there is, similar to (45b), no relative pronoun; furthermore, the head noun occupies its usual syntactic position within the relative clause, so there is no apparent displacement. Mesa Grande Diegueño, a language whose basic word order is best characterized as SOV, has head-internal relative clauses, as shown in (46) from Couro and Langdon (1975). Note that the head noun *gaat* 'cat' appears inside the relative clause and is located between the subject and the verb, consistent with it being the object of the verb. This is the case even though the NP of which it is the head is the subject of the verb in the matrix clause (*chepam* 'got away') — the entire relative clause bears subject morphology in addition to definiteness marking. In such relative clause constructions, there is no evidence of a relative pronoun or, Falk argues, for an anaphorically mediated analysis.

(46) *['ehatt gaat akewii]=ve=ch chepam*
dog cat chase=DEF=SUBJ get.away
'The cat that the dog chased got away.'

In light of these facts, Falk argues that an anaphorically mediated analysis is no more justified for a relative clause construction that lacks a relative pronoun as in (45b) than it is for a head-internal relative clause such as in (46). Instead, he argues that an unmediated analysis should be adopted.[7]

The unmediated analysis that Falk (2010) puts forward seeks to capture the intuition that a noun modified by a relative clause bears two grammatical functions simultaneously, one in the relative clause and the other in the matrix sentence. However, Falk shows that the matter is significantly more complicated than might at first be apparent because the functions do not, in fact, have identical content, and so this cannot be a straightforward case of identity of structure. For example, in (46) the OBJ of 'chased' is 'cat', not 'cat that the dog chased', but the relative clause is part of the SUBJ of 'got away'. Furthermore, notice that definiteness is marked on the NP that is the subject of the matrix clause in (46); it does not appear to be a property of the head noun *gaat* 'cat'. Falk concludes that the element that is apparently shared between the relative clause and the matrix clause has different features in each clause. His proposed unmediated analysis

[7] Culy (1990) also discusses head-internal relative clauses, and provides LFG and HPSG analyses.

involves excluding relevant features such as definiteness, using the restriction operator (Chapter 6, Section 9.4). The other crucial element of Falk's analysis is the RELPRO attribute (which he refers to as OPER), which provides the link between the matrix clause and the relative clause. Falk is careful to point out that RELPRO "is not a pronominal element which is coreferential with the head. There is no anaphoric mediation and the relation between the head and the in-clause position remains direct and unmediated".

Extending this analysis to relative clauses which contain relative pronouns, Falk argues that the relative pronoun does not anaphorically mediate the relationship between the head and in-clause position, but is rather the overt expression of RELPRO and that this realization is necessary in order for pied-piping constructions to be formed. According to this approach, the main difference between clauses with and without relative pronouns is that the relativized element bears an additional discourse function (topic) in the former but not the latter. In providing an analysis of head-internal relative clauses and considering its wider implications, Falk (2010) highlights important issues with the standard analysis of relative clause constructions both generally and within LFG.

1.2.5. Correlatives

Another type of relative clause construction which has received attention in an LFG setting is the correlative construction, in which a relative nominal or pronominal expression appears in a subordinate clause and is resumed by a phrase in the matrix clause. Butt et al. (2007) provide an analysis of Urdu correlatives, illustrated in (47a), while Belyaev and Haug (2014) consider correlatives in Ossetic (a language in which direct objects bear either NOM or GEN case marking), illustrated in (47b).

(47) a. *[jo khaṛ-i hai] [vah laṛki lambi*
which stand-PRF.F.SG be.PRS.3.SG that girl.F.SG.NOM tall.F.SG
hai]
be.PRS.3.SG
'Who is standing, that girl is tall.'

b. *[didinǯ-ətʒ sə čəžg-ʒn ba-lʒvar kotː-aj], [wəz*
flower-PL what girl-DAT PFV-present do-PST.2SG that[GEN]
fetː-on]
see.PFV-PST1sg
'I saw the girl which you gave flowers to.'

In both cases, the syntactic analysis of correlatives is fundamentally the same. The correlative clause appears initially[8] and bears the DIS function, while simultaneously having the appropriate within-clause grammatical function. (At

[8]Butt et al. (2007) note that in Urdu, the subordinate clause containing the relative expression can appear either before or after the matrix clause; following Srivastav (1991), they classify as true correlatives only structures in which the subordinate clause appears initially.

i-structure, the correlative clause bears the discourse function TOPIC.) Belyaev and Haug (2014) provide the following f-structure analysis of the Ossetic correlative construction in (47b):[9]

(48) *didinǯ-ətɜ sə čəžg-ɜn ba-lɜvar kotː-aj, wəz fetː-on*
flower-PL what girl-DAT PFV-present do-PST.2SG that[GEN] see.PFV-PST1sg
'I saw the girl which you gave flowers to.'

$$\left[\begin{array}{ll}
\text{PRED} & \text{`SEE}\langle\text{SUBJ,OBJ}\rangle\text{'} \\
\text{DIS} & \left\{\left[\begin{array}{ll}
\text{PRED} & \text{`GIVE}\langle\text{SUBJ,OBJ,OBJ}_{\text{GOAL}}\rangle\text{'} \\
\text{STYPE} & \text{CORRELATIVE} \\
\text{DIS} & \left\{\left[\begin{array}{ll}
\text{SPEC} & \left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{PRONTYPE} & \text{REL} \end{array}\right] \\
\text{PRED} & \text{`GIRL'}
\end{array}\right]\right\} \\
\text{RELPRO} & \\
\text{OBJ}_{\text{GOAL}} & \\
\text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{INDEX} & \left[\begin{array}{ll} \text{PERS} & 2 \\ \text{NUM} & \text{SG} \end{array}\right] \end{array}\right] \\
\text{OBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`FLOWER'} \\ \text{INDEX} & \left[\begin{array}{ll} \text{NUM} & \text{PL} \end{array}\right] \end{array}\right]
\end{array}\right]\right\} \\
\text{SUBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{INDEX} & \left[\begin{array}{ll} \text{PERS} & 1 \\ \text{NUM} & \text{SG} \end{array}\right] \end{array}\right] \\
\text{OBJ} & \left[\begin{array}{ll} \text{PRED} & \text{`PRO'} \\ \text{DEIXIS} & \text{DIST} \\ \text{ADJ} & \{\ \} \end{array}\right]
\end{array}\right]$$

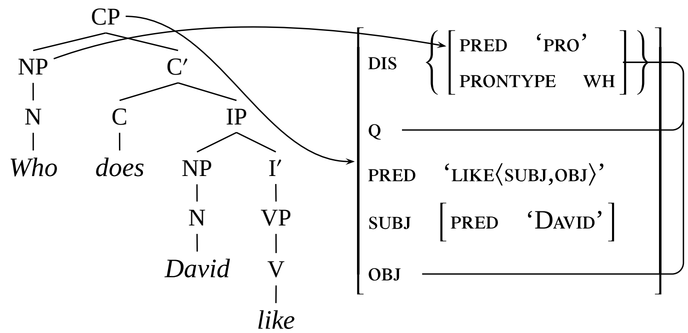
Proposals regarding the semantics of correlatives are briefly reviewed in Section 6.1.

1.3. Constituent Questions

In Chapter 4, Section 2.3, we noted that the question phrase in an English constituent question appears in initial position in the sentence, in the specifier position of CP:

[9] Belyaev and Haug (2014) use the attribute STYPE with value CORREL to mark correlative clauses.

(49) *Who does David like?*



To analyze constructions like (49), the following simplified rule was proposed in Chapter 6, Section 1.2:

(50)
$$\text{CP} \longrightarrow \begin{pmatrix} \text{XP} \\ \downarrow \in (\uparrow \textsc{dis}) \\ (\uparrow \textsc{comp}^{*}\ \textsc{gf}) = \downarrow \end{pmatrix} \begin{pmatrix} \text{C}' \\ \uparrow = \downarrow \end{pmatrix}$$

This rule ensures that the phrase in the specifier position of CP bears the DIS function and also fills a grammatical function within the utterance. We now refine this rule to take into account constraints on the phrase structure category of the fronted phrase and to give a more complete characterization of the path to its within-clause function. We also introduce the Q attribute, whose value is the f-structure of the possibly embedded interrogative pronoun within the initial DIS phrase; see Kaplan and Bresnan (1982) for more discussion of this attribute.

We use the constituent structure metacategory QuesP and the functional abbreviations QDisPath and WhPath in the following reformulation of rule (50):

(51)
$$\text{CP} \longrightarrow \begin{pmatrix} \text{QuesP} \\ \downarrow \in (\uparrow \textsc{dis}) \\ (\uparrow\ \text{QDisPath}) = \downarrow \\ (\uparrow \textsc{q}) = (\downarrow \text{WhPath}) \\ (\uparrow \textsc{q prontype}) =_c \textsc{wh} \end{pmatrix} \begin{pmatrix} \text{C}' \\ \uparrow = \downarrow \end{pmatrix}$$

The annotations on the QuesP node in rule (51) are similar to those on the relative clause rule in (33). The first two annotations require the f-structure corresponding to the QuesP node to fill the DIS role and also to bear some grammatical function defined by the long-distance path QDisPath. The third annotation requires the value of the Q attribute to appear at the end of the long-distance path WhPath within the DIS f-structure; we discuss constraints on WhPath below. The fourth annotation requires the PRONTYPE attribute of the Q f-structure to bear the value WH, ensuring that an interrogative pronoun plays the Q role.

1.3.1. Category of the Displaced Phrase

The first issue is the correct definition of QuesP: which phrasal categories can appear as a DIS constituent in the specifier of CP? These examples are wellformed:

(52) a. NP: *Who do you like?*

b. PP: *To whom did you give a book?*

c. AdvP: *When did you yawn?*

d. AP: *How tall is Chris?*

Thus, we define QuesP in (51) above as the following disjunction of categories:

(53) QuesP [English] ≡ {NP | PP | AdvP | AP}

1.3.2. Grammatical Function of the Displaced Phrase

Next, we define QDisPath, the long-distance path involved in question formation. Constraints on QDisPath appear to be largely similar to those defined for TpczPath in (20) of this chapter (though see Postal 1998 for a discussion of differences between the two types of paths):

(54) a. *Chris, we like.*

b. *Who do you like?*

(55) a. *Chris, we think that David saw.*

b. *Who do you think that David saw?*

(56) a. **Chris, we whispered that David saw.*

b. **Who did you whisper that David saw?*

(57) a. **Chris, [that David saw ___] surprised me.*

b. **Who did [that David saw ___] surprise you?*

(58) a. *This hammer, we smashed the vase with.*

b. *What did you smash the vase with?*

(59) a. **Chris, we think that David laughed when we selected.*

b. **Who did you think that David laughed when we selected?*

Therefore, we can provisionally provide the same definition for QDisPath in English as we gave for TpczPath in (20). Future research may reveal various additional refinements:

(60) QDisPath [English] ≡ SSC & BVC & TAC

1.3.3. Grammatical Function of the Interrogative Element

In (44), we provided a constraint on RelPath, the path to the relative pronoun within the initial dis phrase in a relative clause. Similarly, we must define WhPath, the path to the interrogative element within the initial dis phrase in a constituent question. Like the relative pronoun, an interrogative pronoun may be embedded inside the initial phrase, appearing as a possessor (61a) or the possessor of a possessor (61b), or as the obj of the fronted argument (61c):

(61) a. *[Whose book] did you read?*

b. *[Whose brother's book] did you read?*

c. *[In which room] do you teach?*

However, WhPath is more constrained than RelPath:

(62) a. **[The cover of which report] did you design?*
(cf. *Which report did you design the cover of?*)

b. *the report [the cover of which] I designed*

(63) a. **[The height of the lettering on the cover of which report] does the government prescribe?*

b. *the report [the height of the lettering on the cover of which] the government prescribes*

(64) a. **[Faster than whom] can you run?*

b. *the man [faster than whom] I can run*

(65) a. **[Proud of whom] are you?*

b. *the kind of person [proud of whom] I could never be*

Therefore, we propose the following definition of WhPath in English:

(66) English WhPath:

$\{\text{POSS}^* \mid \text{OBJ}\}$

Webelhuth (1992) provides more discussion of constraints on pied piping in Germanic languages, showing that pied piping constraints in English constituent questions are the same as in other Germanic languages.

1.3.4. The Complementizer-Adjacent Extraction Constraint

As discussed in Chapter 6, Section 11.2, question formation is restricted by the Complementizer-Adjacent Extraction (CAE) constraint (sometimes referred to as the *that*-trace or comp-trace effect). This constraint blocks subject extraction in long-distance dependencies when a complementizer is present; notice the difference in grammaticality that arises in the case of extraction of a subj (67a) versus a non-subject (67b):

(67) a. *Who do you think (*that) ___ saw Kim?*

b. *Who do you think (that) Kim saw ___?*

The presence of an adverb has an ameliorating effect, permitting SUBJ extraction even in the presence of the complementizer (Bresnan 1977):

(68) *Who did you say that, just a minute ago, ___ sneezed?*

One approach to the CAE constraint is proposed by Falk (2002b, 2006), framed within his PIVOT/$\widehat{\text{GF}}$ approach to subjecthood (see Chapter 2, Section 1.5). Recall that Falk (2006) defines PIVOT as the grammatical function that connects its own clause to other clauses. In (67a), for instance, the PIVOT is *who*. To account for the CAE constraint, Falk proposes the generalization in (69):

(69) CAE generalization according to Falk (2006):

If $\phi^{-1}(\uparrow \text{ PIVOT})$ exists,[10] one of the nodes in $\phi^{-1}(\uparrow)$ must immediately dominate one of the nodes in $\phi^{-1}(\uparrow \text{ PIVOT})$.

Falk's intention is for the immediate dominance relation referred to in (69) to be 'f-structure aware', and to this end he defines the 'f-ID relation':

(70) Definition of the f-ID relation according to Falk (2006):

For any f-structures f_1 and f_2, f_1 f-IDs f_2 ($f_1 \rightarrow_f f_2$) if and only if there exists a node n_1 in $\phi^{-1}(f_1)$ and a node n_2 in $\phi^{-1}(f_2)$ such that n_1 immediately dominates n_2.

Falk's final formalization of the CAE constraint is:

(71) CAE constraint according to Falk (2006, 133), associated with the complementizer *that*:

$\phi^{-1}(\uparrow \text{ PIVOT}) \Rightarrow \uparrow \rightarrow_f (\uparrow \text{ PIVOT})$

As a constraint included in the lexical entry of complementizer *that* in English, this allows (67b) but rules out (67a). The guiding intuition behind the constraint is that a clause containing the complementizer *that* must contain its own PIVOT, which must not be displaced; the PIVOT of a *that*-clause must be immediately dominated by some node (here, the IP node) that maps to the same f-structure as the complementizer.

Falk's analysis is integrated with his approach to subjecthood, which is clearly an advantage. However, it does not account for the Adverb Effect, the ameliorating effect of an adverbial expression's presence illustrated in (68), because an intervening adverb does not change the f-structure relations which hold between the PIVOT and the complementizer.

[10] ϕ^{-1} is the relation that maps f-structures to c-structure nodes: see Chapter 6, Section 10.3. $\phi^{-1}(\uparrow \text{ PIVOT})$ is an existential constraint that holds if there is some c-structure node corresponding to $(\uparrow \text{ PIVOT})$ via the ϕ^{-1} relation.

In Chapter 6, Section 11.2, we presented Asudeh's (2009) analysis of the CAE constraint: briefly, Asudeh proposes a constraint, to be included in the lexical entry of the complementizer *that*, which rules out the ungrammatical sequences of words on the basis of string precedence. Asudeh (2009) cites the Adverb Effect as a reason why the CAE constraint must be treated as a precedence-based phenomenon rather than a dominance-based one, as in Falk's analysis. Asudeh's (2009) own analysis of the CAE constraint makes crucial reference to linear order relations and does account for the Adverb Effect. His formulation of the CAE constraint is given in example (179) of Chapter 6, Section 179, repeated here:

(72) CAE Constraint, Asudeh (2009), formal version:

$\neg[\textsc{realized}(\succ\ \textsc{subj}) \wedge (\textsc{dis} \in (\succ\ \textsc{subj}))]$

Asudeh's CAE constraint rules out a situation in which the word following the complementizer has a subject which is both phonologically REALIZED and the head of an unbounded dependency. When an adverb follows the complementizer *that*, as in (68), the constraint in (72) is satisfied.

1.3.5. Multiple Questions

Thus far, we have considered English constituent questions that include a single initial question phrase. For languages allowing multiple question phrases occurring together in a single sentence, there is typological variation: one question phrase may appear initially (so-called simple fronting), as in English (73a); all question phrases may be displaced (multiple fronting), as in Russian (King 1995; 73b); or all question phrases may occupy the same position as they would in a declarative sentence (in situ), as in Japanese (73c).

(73) a. *What did Charlie put where?*

b. *Kogda kto udaril Borisa?*
when who hit Boris
'Who hit Boris when?'

c. *Mari-ga doko-de ojoosan-ni nani-o eranda ka*
Mari-NOM where-LOC daughter-DAT what-ACC choose.PST Q
'What did Mari choose for her daughter where?'

Mycock (2006) provides an LFG approach to the typology of questions. Key to her analysis is the proposal that question phrases must be focused. Thus, a more complete analysis of a simple constituent question in English such as (49) would include the i-structure in (74), which captures the FOCUS status of the question phrase. In English, this focus status is marked syntactically: the question word bearing the grammatical function OBJ is displaced to initial position, and hence also bears the function DIS:[11]

[11] On the representation of information structure in LFG, see Chapter 10.

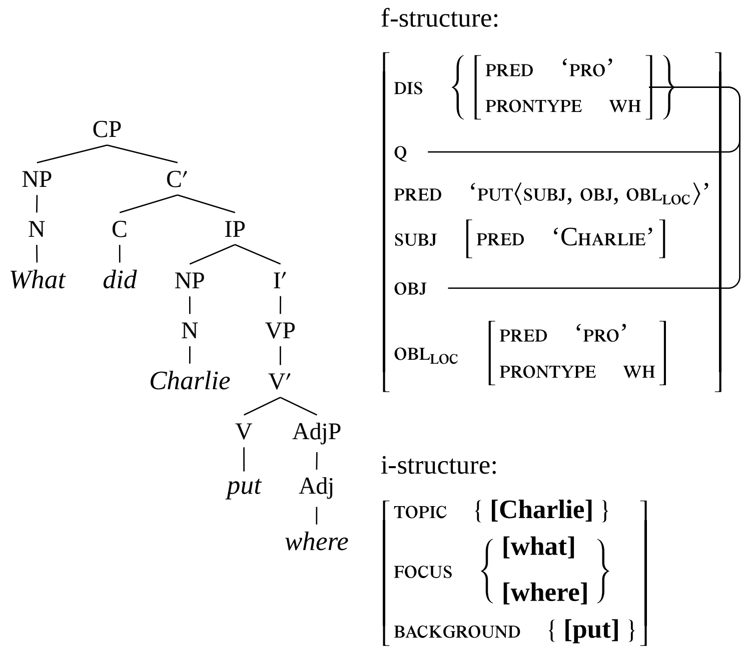
(74)
$$\begin{bmatrix} \text{TOPIC} & \{\ \textbf{[David]}\ \} \\ \text{FOCUS} & \{\ \textbf{[who]}\ \} \\ \text{BACKGROUND} & \{\ \textbf{[like]}\ \} \end{bmatrix}$$

In some languages, such as Russian, the FOCUS status of all question phrases is signaled syntactically; that is, they occupy a syntactic position associated with the discourse function FOCUS and hence all appear initially, as in (73b). Of course, focus status need not be marked by syntactic means only. Mycock (2006) argues that the focus status of question phrases in Japanese, which appear in situ (73c), is marked prosodically. Constituent questions in this language do not involve a long-distance dependency and question phrases do not bear the function DIS, but at i-structure — like their Russian counterparts — all question words are members of the FOCUS set according to Mycock (2006). What of the English-type formation, which involves a single question phrase bearing the function DIS appearing in initial position and all other question phrases in situ, as in (73a)? Mycock claims that in-situ question words in English are prosodically marked for focus status, like those in Japanese. Therefore, while the c-structures for English, Russian, and Japanese multiple constituent questions differ according to whether or not question phrases bear the function DIS, in each case the i-structures are fundamentally the same: they contain a FOCUS set which includes all of the question words in the sentence.

Whether all in-situ languages should be analyzed in the same way is an interesting question. In his LFG analysis of Mandarin Chinese constituent questions, Huang (1993) shows that although these constructions do not involve long-distance dependencies, the same sorts of scope phenomena found in English constituent questions can also be found in Chinese. Huang uses inside-out functional uncertainty (Chapter 6, Section 1.3) in his analysis to capture the similarities between questions in English and Chinese. Mycock (2006) considers an apparent island effect in Japanese, but it emerges that this may be an issue of prosody rather than syntax (see Deguchi and Kitagawa 2002). It remains to be determined beyond doubt whether in-situ languages may be subject to exactly the same kinds of syntactic constraints as languages which involve displacement of question phrases in multiple constituent questions.

We assume that only question words that undisputedly participate in a long-distance dependency are the value of the Q attribute at f-structure. This distinguishes displaced question words from those that appear in situ under our approach. This difference is illustrated by the following analysis of an English multiple constituent question, which includes one displaced question word (*what*) and one in-situ question word (*where*):

(75) *What did Charlie put where?*



The kind of ‘regular’ constituent questions that we have considered so far are the most well studied. LFG research has also investigated a variety of other constructions that include question phrases. Mycock (2004, 2006) offers an LFG analysis of the Q-expletive (also *wh*-expletive or *wh*-scope marking) construction, in which a question phrase takes scope over a clause higher than the one in which it appears. The question word’s extended scope is marked in some languages, including Hungarian, by the presence of another element, represented in the gloss as WHAT.

(76) *István mi-t gondol, [hogy Mari mi-t*
Stephen.NOM WHAT-ACC think.PRS.3SG that Mary.NOM WHAT-ACC
mond-ott, [hogy János ki-t hív-ott fel]]?
say-PST.3SG that John.NOM who-ACC call-PST.3SG VM
‘Who does Stephen think that Mary said that John called?’

Mycock adopts the position that only the final question word (in the example above, *kit*) is the ‘true’ question word; any higher ones are expletives associated with a ‘true’ question expression. The Q-expletive is semantically empty, but it is syntactically and/or prosodically prominent. For instance, in (76) the Q-expletive (*mit*) occupies immediately preverbal Focus position, just as the ‘true’ question word *kit* does in the most deeply embedded clause. The Q-expletive’s presence thus serves to focus ‘by proxy’ the content of the phrase with which it is associated (which Mycock claims is the entire clause within which the ‘true’ question words appear in Hungarian). In this way, the Q-expletive stands in for the relevant expression in a higher clause. See Mycock (2006) for full details of an LFG analysis of scope-marking constructions, including the Q-expletive construction.

Other work on questions in LFG has considered the information structure status of question words and phrases and how this interacts with syntactic structure. We have seen that in 'regular' information-seeking constituent questions there is evidence that the question expression has FOCUS status at i-structure, but there are other possibilities. On the basis of question formation data from 15 languages, Mycock (2013) proposes that question words can bear other discourse functions as well (BACKGROUND, COMPLETIVE, TOPIC), just like non-question words. For instance, following Butt (2012), Mycock proposes to analyze question words in echo questions as BACKGROUND rather than FOCUS. This provides an explanation for syntactic differences between these two types of constituent questions. Butt (2014b) also deals with non-canonical constituent questions and the role that information structure plays in the analysis of Hindi-Urdu. Butt draws on the work of Mycock (2006) on questions and Krifka (2008) on information structure and the concept of Common Ground Management to give an analysis of the immediately postverbal position in Hindi-Urdu as a second focus position with particular interpretational characteristics. Butt (2014b) also presents an analysis of polar questions including the question marker *kya* in Hindi-Urdu, which provides a similarly fine-grained approach to their distinct information structural properties.

1.4. *Tough* Constructions

In certain constructions including predicates such as *tough* ('*tough*-movement' constructions), the complement of the *tough* predicate is a non-finite subordinate clause with a missing object, and the subject of the *tough* predicate is interpreted as controlling the missing object.

(77) *This race is tough [to finish ___].*
(cf. *It is tough [to finish this race].*)

As Dalrymple and King (2000) show, the missing object can be embedded arbitrarily deeply in the complement of a *tough* construction.

(78) *This book is tough [to get her [to avoid [reading ___]]].*

An early LFG-based analysis of *tough* constructions was proposed by Kaplan and Bresnan (1982), according to which the subject of *tough* functionally controls a TOPIC as well as the OBJ in the subordinate clause. In contrast, Dalrymple and King (2000) analyze *tough* constructions as involving a long-distance dependency in which the gap object is anaphorically controlled by the matrix subject. A functional control analysis, requiring identity between the matrix subject (the controller) and the complement object (the controllee), is rejected because, for example, there is case mismatch between the filler and the gap:

(79) a. *It is tough to find him.*

b. **Him is tough to find* ___.

c. *He is tough to find* ___.

Under anaphoric control, there is no expectation of case preservation because the f-structure for the subject of *tough* is not the same as the f-structure for the object in the complement clause; rather, two different f-structures are anaphorically related.

Following a body of work by, among others, Lasnik and Fiengo (1989), Jacobson (1992a), Pollard and Sag (1994), Kim (1995), and Clark (2000), Dalrymple and King (2000) claim that the matrix subject is assigned a thematic role. Evidence for this is that, for example, the subject cannot be replaced by an expletive, and the construction is incompatible with true idioms (Nunberg et al. 1994). According to Dalrymple and King's (2000) analysis, then, *tough* predicates select for a SUBJ and a COMP, with the SUBJ anaphorically controlling an unpronounced DIS element in the subordinate clause. The usual identity relation holds between the DIS element and the OBJ of COMP. In this way, the matrix SUBJ and the OBJ in COMP are related to one another via both anaphoric and functional control. The SUBJ in COMP's reference is determined by arbitrary anaphoric control (Chapter 15, Section 5).

(80) *Moths are tough to kill.*

$$\left[\begin{array}{ll} \text{PRED} & \text{`TOUGH}\langle\text{SUBJ,COMP}\rangle\text{'} \\ \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`MOTH'}\\ \text{INDEX} & \left[\text{NUM} \quad \text{PL}\right]\end{array}\right] \\ \text{COMP} & \left[\begin{array}{ll} \text{PRED} & \text{`KILL}\langle\text{SUBJ,OBJ}\rangle\text{'}\\ \text{DIS} & \left\{\left[\text{PRED} \quad \text{`PRO'}\right]\right\}\\ \text{SUBJ} & \left[\text{PRED} \quad \text{`PRO'}\right]\\ \text{OBJ} & \end{array}\right]\end{array}\right]$$

This biclausal analysis is supported by, for instance, the interaction of the *tough* predicate and a *for*-phrase, as shown in (81). Notice that the *for*-phrase can act as an overt controller of the SUBJ in COMP:

(81) *This race is tough for me to finish.*

Dalrymple and King (2000) also discuss syntactic constraints on the path between filler and gap in *tough* constructions. Notably, it is not possible for the gap in this construction to bear any grammatical function other than OBJ. Dalrymple and King (2000) show that this OBJ can be inside an adjunct or oblique phrase, for instance:

(82) *This violin is easy to play the sonata on* ___.

Revising Dalrymple and King's original rule slightly in order to bring it in line with our assumptions about f-structure and the DIS function, the relevant constraints are captured by the constraint in (83), which appears in the lexical entry of the *tough* predicate:

(83) $(\uparrow \textsc{comp}\ \textsc{xcomp}^*\ (\{\textsc{obl}_\theta |\ \textsc{adj}\})\ \textsc{obj}) \in (\uparrow \textsc{comp}\ \textsc{dis})$

According to this constraint, the complement (COMP) of a *tough*-predicate has a DIS attribute, one of whose members controls an unexpressed OBJ which may be embedded inside any number of XCOMPs, and may appear inside an oblique or adjunct phrase. This constraint rules out a tensed complement clause on the path: for many speakers, only XCOMP can appear on the permissible path, and in English XCOMP must be non-finite. A different path specification is required for speakers like Kaplan and Bresnan (1982), who allow finite complements on the path; Kaplan and Bresnan classify example (84) as grammatical:

(84) %*Mary is tough for me to believe that John would ever marry* ___.

Note that the long-distance path specification in (83) is very different from the path that is relevant for, for example, English topicalization (20); thus, *tough* constructions neatly illustrate that long-distance dependencies and the constraints upon them may vary not only across languages, but also within a single language.

Dalrymple and King (2000) observe that another set of predicates, including *need* and *require*, also involve a 'missing object', but display distinct properties. Their interaction with a *for*-phrase, for one, is different:

(85) **The car needs/requires for him washing* ___.

Further, data show that the dependency involved is not arbitrarily long but bounded in the case of *need*-type predicates:

(86) a. *This house needs/requires renovating* ___.

b. **This house needs/requires trying [to renovate* ___*]*.

In line with work by Barron (1999), Dalrymple and King (2000) analyze *need*-type predicates as complex predicates that appear in a monoclausal structure; no long-distance dependency is established. The f-structures of *need*-type and *tough*-type predicates are therefore distinct; compare (80) and (87).

(87) *The car needs washing.*

$$\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{need}\langle\textsc{washing}\langle\textsc{subj}\rangle\rangle\text{'} \\ \textsc{subj} & \left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{car}\text{'} \\ \textsc{def} & + \\ \textsc{index} & \left[\begin{array}{ll} \textsc{num} & \textsc{sg} \end{array}\right] \end{array}\right] \end{array}\right]$$

2. RESUMPTIVE PRONOUNS

Up to this point, we have considered only constructions in which the within-clause function of a displaced phrase corresponds to the gap in a filler-gap dependency. This is, of course, not the only possibility: many languages require a resumptive pronoun, as in example (88a) from Swedish (Doron 1982) and example (88b) from Irish (McCloskey 2002):

(88) a. *Kalle letar efter en bok som han inte vet hur* **den** *slutar.*
Kalle looks for a book that he not knows how **it** ends
'Kalle is looking for a book that he does not know how (it) ends.'

b. *an ghirseach a-r ghoid na síogaí* **í**
the girl COMP-PST stole the fairies **her**
'the girl that the fairies stole away'

The challenge for any LFG analysis of resumptives is to deal with the apparent violation of wellformedness which arises. If the resumptive pronoun is the same as any other pronoun, then both it and the DIS phrase that binds it contribute PRED values to the same f-structure, in violation of Consistency (Chapter 2, Section 4.6.3).

Falk (2002b) proposes that a pronoun in a language with resumptive pronouns makes one of two different f-structure contributions: in its use as a standard pronoun it contributes a PRED attribute with value 'PRO' to the f-structure, while in its resumptive use, it does not contribute a PRED value, but its f-structure is required to be identical with a member of the DIS set. Under the second option, the same kind of long-distance dependency is established as in the filler-gap structures that we have examined so far. This dual nature of pronouns in languages with resumptive pronouns accounts for the differences in syntactic constraints restricting 'ordinary' pronouns compared to those restricting resumptive pronouns: according to Falk the type of dependencies involved are fundamentally different, and therefore it is unsurprising that their properties are not necessarily the same.

What this analysis fails to capture, Asudeh (2004, 2012) argues, is McCloskey's Generalization (McCloskey 2002, page 192): resumptive pronouns are, in fact, ordinary pronouns, and do not take on special forms in their use as resumptives. Asudeh observes that under Falk's analysis, the similarities between ordinary and resumptive pronouns are a matter of coincidence. Asudeh's own analysis differs in treating resumptive pronouns as no different from ordinary pronouns in terms of their syntactic specification.

This does not mean that all resumptive pronoun constructions are identical at f-structure, however. Asudeh (2012), following up on McCloskey (2002), shows that an important distinction can be made between syntactically active resumptives (SARs) and syntactically inactive resumptives (SIRs), which differ with respect to the set of properties that they exhibit. SIRs display gap-like properties, and involve the kind of long-distance dependency that we have seen exemplified for English in this chapter already. Importantly, SIRs are sensitive to constraints such as the across-the-board constraint (Section 1.1.1). By contrast, SARs exhibit no such gap-like properties: an across-the-board violation would not result in ungrammaticality, for instance. Asudeh (2012) identifies resumptive pronouns in Swedish (88a) and Vata as SIRs, and resumptive pronouns in Irish (88b) and Hebrew to be SARs. In other LFG work, Camilleri and Sadler (2011) argue that Maltese too has SARs.

Asudeh (2012) proposes that the fact that SIRs display gap-like properties means that they should be analyzed in the same way as long-distance dependencies with a gap; that is, that constructions including SIRs involve functional control. However, this gives rise to an apparent Consistency violation, as noted above: if the resumptive pronoun in a SIR construction is an ordinary pronoun, as Asudeh argues, then both it and the DIS phrase contribute PRED values to the same f-structure, in violation of Consistency (Chapter 2, Section 4.6.3) — an issue that Falk (2002b) addresses by allowing resumptive pronouns to lack a PRED value, in contrast to their ordinary pronoun counterparts. Asudeh's approach is to employ the restriction operator (Chapter 6, Section 9.4) in the specification of the relation between the DIS element and the resumptive pronoun to remove the PRED attribute and its value, as outlined in general terms in (89) (adapted from Asudeh 2012, page 147). The expression in (89) specifies a path SIRPath through the f-structure leading to the resumptive pronoun, similar to RTopicPath in Section 1.2. The f-structure at the end of that path is the resumptive pronoun in the relative clause, which is required to be identical with the DIS f-structure except for the PRED attribute and its value.[12]

(89) $(\uparrow \textsc{dis})|_{\textsc{pred}} = (\uparrow \text{SIRPath})|_{\textsc{pred}}$

This means that the f-structures for a long-distance dependency with a gap and a SIR construction are fundamentally the same, since both involve a filler-gap dependency in which the DIS f-structure also bears a grammatical function within the clause. SIRPath is defined in (90) for Swedish, adapted from Asudeh (2012, page 254):

(90) $\text{SIRPath [Swedish]} \equiv \textsc{gf}^{*} \underset{((\rightarrow \textsc{pred}) = (\uparrow\ \textsc{dis}\ \textsc{pred}))}{\textsc{gf}}$

The off-path constraint in this example specifies that the PRED of the resumptive pronoun (removed by the restriction operator, as specified in (89)) is replaced by the PRED of the DIS element. The resulting f-structure for a Swedish subject resumptive example is:

(91) *Vem$_i$ trodde Maria att han$_i$ skulle fuska?*
who thought Maria that he would cheat

[12] We follow Asudeh (2012) in making the simplifying assumption that the value of the DIS attribute (which he calls UDF) is a single f-structure, not a set. In the analysis of languages in which the value of DIS is a set of f-structures, a *local name* (Chapter 6, Section 5) must be used to ensure that the constraints in (89) and (90) refer consistently to the same member of the DIS set.

‘Who did Maria think that (he) would cheat?’

$$\left[\begin{array}{ll} \text{PRED} & \text{‘THINK}\langle\text{SUBJ,COMP}\rangle\text{’} \\ \text{DIS} & \left[\begin{array}{ll} \text{PRED} & \text{‘PRO’} \\ \text{PRONTYPE} & \text{WH} \\ \text{CONCORD} & \left[\text{CASE} \quad \text{NOM}\right] \\ \text{INDEX} & \left[\begin{array}{ll} \text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{GEND} & \text{M} \end{array}\right] \end{array}\right] \\ \text{Q} & \\ \text{SUBJ} & \left[\text{PRED} \quad \text{‘MARIA’}\right] \\ \text{COMP} & \left[\begin{array}{ll} \text{PRED} & \text{‘CHEAT}\langle\text{SUBJ}\rangle\text{’} \\ \text{COMPFORM} & \text{ATT} \\ \text{SUBJ} & \end{array}\right] \end{array}\right]$$

The only significant difference between this f-structure and one which does not contain a subject resumptive, as shown in (92), is that values for features GEND and CASE are absent in the latter. This is because only the Swedish personal pronoun *han* contributes this information; the question pronoun *vem* does not.

(92) *Vem$_i$ trodde Maria ___$_i$ skulle fuska?*
who thought Maria ___ would cheat
‘Who did Maria think would cheat?’

$$\left[\begin{array}{ll} \text{PRED} & \text{‘THINK}\langle\text{SUBJ,COMP}\rangle\text{’} \\ \text{DIS} & \left[\begin{array}{ll} \text{PRED} & \text{‘PRO’} \\ \text{PRONTYPE} & \text{WH} \\ \text{INDEX} & \left[\begin{array}{ll} \text{PERS} & 3 \\ \text{NUM} & \text{SG} \end{array}\right] \end{array}\right] \\ \text{Q} & \\ \text{SUBJ} & \left[\text{PRED} \quad \text{‘MARIA’}\right] \\ \text{COMP} & \left[\begin{array}{ll} \text{PRED} & \text{‘CHEAT}\langle\text{SUBJ}\rangle\text{’} \\ \text{SUBJ} & \end{array}\right] \end{array}\right]$$

In this way, Asudeh addresses the issue of Consistency while preserving McCloskey’s Generalization (McCloskey 2002, page 192): resumptive pronouns in SIR structures are just ordinary pronouns that can participate in a long-distance dependency when licensed by the rule in (89).

By contrast, the fact that SARs do not exhibit gap-like properties indicates that they are anaphorically bound pronouns, and thus Asudeh proposes a different analysis for SARs, as this Hebrew example demonstrates:

(93) *ʔet ha-yeled$_i$ she rina ʔohevet ʔoto*
ACC the-boy COMP Rina loves him
'the boy that Rina loves (him)'

$$
\left[\begin{array}{ll}
\text{PRED} & \text{`BOY'}\\
\text{DEF} & +\\
\text{CONCORD} & \left[\text{CASE}\quad \text{ACC}\right]\\
\text{ADJ} & \left\{\left[\begin{array}{ll}
\text{DIS} & \left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\\ \text{PRONTYPE} & \text{REL}\end{array}\right]\\
\text{RELPRO} & \\
\text{PRED} & \text{`LOVE}\langle\text{SUBJ,OBJ}\rangle\text{'}\\
\text{COMPFORM} & \text{SHE}\\
\text{SUBJ} & \left[\text{PRED}\quad \text{`RINA'}\right]\\
\text{OBJ} & p\left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3\\ \text{NUM} & \text{SG}\\ \text{GEND} & \text{M}\end{array}\right]\end{array}\right]
\end{array}\right]\right\}
\end{array}\right]
$$

Here, the f-structure for the pronoun is labeled p: it is a standard pronominal f-structure, contributing a PRED attribute with value 'PRO'. Asudeh (2012) analyses the binding relationship between the SAR resumptive pronoun and the relevant DIS set member as being established by the complementizer system in Hebrew. Crosslinguistically, this is subject to variation: Asudeh argues that in Irish the relationship is established by a particular complementizer (*aN*), for example. We consider the semantics of resumptive pronouns in Section 6.4.

3. MORPHOLOGICAL MARKING OF LDD PATHS

Some languages signal long-distance dependency constructions by means of special morphological or phonological forms, as noted by Clements and Ford (1979) for Kikuyu, McCloskey (1979) for Irish, Chung (1982) for Chamorro, and Georgopoulos (1985) for Palauan. These constructions were first analyzed in LFG by Zaenen (1983) in work on Kikuyu, based on the early LFG treatment of long-distance dependencies as relations betwen c-structure positions (Kaplan and Bresnan 1982). Here we review the Kikuyu data that Zaenen (1983) originally treated, presenting a distinct analysis that focuses on f-structure rather than c-structure relations.[13] We then turn to a discussion of the Irish complementizer system, which also signals the presence of a long-distance dependency by the use of different complementizers.

3.1. Kikuyu

As discussed by Zaenen (1983) and in more detail by Clements and Ford (1979), in affirmative declarative Kikuyu sentences the verb is associated with a downstep tone.[14] This downstep tone affects the phonology of the words following the verb: the downstep turns a sequence of low tones into high tones in the immediately proceeding phrasal category. In (94), a downstep is associated with the two verbs *ɛ̀:ꜝrírɛ̀* 'tell' and *átɛ̀mírɛ̀* 'cut':

(94) *Kamaú ɛ̀:ꜝrírɛ̀ Ka:nákɛ̀ áté Káriókꜝí átɛ̀mírɛ̀ mótě*
Kamau SUBJ.tell.PST Kanake that Kariũki SUBJ.cut.PST tree
'Kamau told Kanake that Kariũki cut the tree.'

The downstep associated with *ɛ̀:ꜝrírɛ̀* 'tell' affects the words *áté* 'that' and *Káriókꜝí* 'Kariũki', whose citation forms are:

(95) a. *ate*
b. *Kariokǐ*

As Zaenen (1983) shows, the explanation for these difference can be ascribed to the tonal shift imposed by the verb *ɛ̀:ꜝrírɛ̀* 'tell'.

Interestingly, however, this tone change does not appear within the domain of a long-distance dependency:

(96) *nóo Kámaú ɛ̀:ꜝrírɛ̀ Ka:nákɛ̀ áte otɛmírɛ̀ mote*
who Kamau SUBJ.tell.PST Kanake that SUBJ.cut.PST tree
'Who did Kamau tell Kanake that ___ cut the tree?'

The question word *nóo* 'who' bears the DIS function and also fills the role of the SUBJ of the verb *otɛmírɛ̀* 'cut' in the subordinate COMP. The downstep that would be expected to appear on both the matrix and subordinate clause verb does not occur, and the effect that this downstep would have had on the following words is not present.[15] As Clements and Ford (1979) and Zaenen (1983) show, the absence of the downstep tone marks the *domain of extraction* of the fronted interrogative pronoun. Here, the domain of extraction is the f-structure for the entire sentence.

We propose that every f-structure in the domain of extraction in Kikuyu is marked with the attribute-value pair ⟨LDD, +⟩:

[13] This analysis is based on unpublished joint work by Ron Kaplan, John Maxwell, Annie Zaenen, and Mary Dalrymple.

[14] In the following examples, high tones are marked with an acute accent, downstep tones are marked with !, and low tones are unmarked.

[15] The high tone on the initial syllable of *ate* 'that' is spread from the final high tone of the preceding word *Káriókꜝí* 'Kariũki' by an independent rule.

(97) Each attribute on the path relating a member of the DIS set to its within-clause grammatical function must be an attribute of an f-structure that also contains the pair ⟨LDD, +⟩.

In (98) this constraint is satisfied, since the f-structures labeled *t* and *c* both contain the attribute-value pair ⟨LDD, +⟩:

(98) *nóo Kámaú ɛ́:ꜜrírɛ́ Ka:nákɛ́ áte otɛmírɛ́ mote*
who Kamau SUBJ.tell.PST Kanake that SUBJ.cut.PST tree
'Who did Kamau tell Kanake that ___ cut the tree?'

$$t\left[\begin{array}{ll} \mathrm{DIS} & \left\{\left[\begin{array}{ll}\mathrm{PRED} & \text{`PRO'}\\ \mathrm{PRONTYPE} & \mathrm{WH}\end{array}\right]\right\}\\ \mathrm{Q} & \\ \mathrm{PRED} & \text{`TELL}\langle\mathrm{SUBJ,OBJ,COMP}\rangle\text{'}\\ \mathrm{LDD} & +\\ \mathrm{SUBJ} & \left[\begin{array}{ll}\mathrm{PRED} & \text{`KAMAU'}\end{array}\right]\\ \mathrm{OBJ} & \left[\begin{array}{ll}\mathrm{PRED} & \text{`KANAKE'}\end{array}\right]\\ \mathrm{COMP} & c\left[\begin{array}{ll}\mathrm{PRED} & \text{`CUT}\langle\mathrm{SUBJ,OBJ}\rangle\text{'}\\ \mathrm{COMPFORM} & \text{ÁTE}\\ \mathrm{LDD} & +\\ \mathrm{SUBJ} & \\ \mathrm{OBJ} & \left[\begin{array}{ll}\mathrm{PRED} & \text{`TREE'}\end{array}\right]\end{array}\right]\end{array}\right]$$

Within the domain marked by the attribute-value pair ⟨LDD, +⟩, spreading of the downstep tone does not occur.

To constrain the path defining a long-distance dependency in Kikuyu, ensuring that the path passes only through f-structures that are appropriately marked with the LDD feature, we use *off-path constraints*, defined and discussed in Chapter 6, Section 6 and in Section 1 of this chapter. We assume a simplified definition of QDISPATH for Kikuyu, representing it as COMP* GF:[16]

(99) $$(\uparrow \underset{(\leftarrow \mathrm{LDD}) = +}{\mathrm{COMP}^*} \underset{(\leftarrow \mathrm{LDD}) = +}{\mathrm{GF}}) \in (\uparrow \mathrm{DIS})$$

In (99), the expression $\underset{(\leftarrow \mathrm{LDD}) = +}{\mathrm{COMP}^*}$ refers to zero or more occurrences of the constrained attribute $\underset{(\leftarrow \mathrm{LDD}) = +}{\mathrm{COMP}}$. The metavariable ← in this off-path constraint

[16] It is likely that grammatical functions other than COMP are allowed in the extraction domain in Kikuyu. In a full treatment of Kikuyu long-distance dependencies, the equation in (99) should be enriched appropriately to properly characterize the full range of permitted relations between the initial question word and its grammatical function within the clause, as was done for English in (60).

refers to the f-structure that contains the attribute on which the constraint is written. Thus, the off-path constraint (←LDD) = + ensures that each f-structure that has a COMP attribute on the path also has the attribute LDD with value +. The equation in (99) associates the constraint (←LDD) = + with every attribute on the path, and marks the entire Kikuyu domain of extraction with the LDD feature, as desired.

3.2. Irish

Asudeh (2004, 2012) explores the marking of long-distance dependencies in Irish, in which morphophonology varies according to the precise type of long-distance dependency construction: the form of the complementizer is dependent on whether the path terminates in a gap or a resumptive pronoun. In the non-past, two of the complementizers have the same form, but they are distinct in triggering different mutations on the following word. The complementizer used with a filler-gap construction triggers lenition mutation (and is therefore often glossed as *aL*), while the one that co-occurs with a resumptive pronoun triggers nasalization mutation (and therefore is often glossed as *aN*). Asudeh (2012) cites the following examples from McCloskey (1979).

(100) a. *an scríbhneoir a mholann na mic léinn* ___
the writer *aL* praise the students
'the writer whom the students praise'

b. *an scríbhneoir$_i$ a molann na mic léinn é$_i$*
the writer *aN* praise the students him
'the writer whom the students praise (him)'

Note the lack of relative pronouns in Irish relative clauses. This means that the specifier of CP position is unoccupied in an Irish relative clause, though not in Irish constituent questions and cleft constructions. The phrase structure rule in (101) allows for the analysis of relative clauses in Irish, where the specifier of CP is unfilled. as well as constituent questions and clefts with a phrase filling the specifier position:[17]

(101)
$$\text{CP} \longrightarrow \left\{ \begin{array}{c} \text{XP} \\ \downarrow \in (\uparrow\ \text{DIS}) \end{array} \middle| \begin{array}{c} \epsilon \\ (\uparrow\ \text{DIS} \in \text{PRED}) = \text{`PRO'} \\ (\text{ADJ} \in \uparrow) \end{array} \right\} \begin{array}{c} \text{C}' \\ \uparrow = \downarrow \end{array}$$

According to the rule in (101), when the specifier of CP is not filled by an XP at c-structure (hence ϵ for the empty string), the DIS set includes a member whose feature PRED has the value 'PRO'.

The two Irish long-distance dependency constructions that Asudeh analyses differ in another significant respect. When the long-distance dependencies involves multiple clauses, *aL* appears in every clause on the path between filler and

[17]This is a simplified version of the phrase structure rule proposed in Asudeh (2012, page 168), which also includes a meaning constructor that is essential for semantic composition. For a similar analysis of the pronoun-less relative clause construction in English, see Section 6.

gap. By contrast, when a long-distance dependency involves multiple clauses and a resumptive pronoun, a second pattern emerges: *aN* appears in the 'top' clause in the dependency (the furthest clause from the resumptive pronoun, but the one closest to its binder), and all intervening clauses contain a third complementizer *go* instead.[18] The full long-distance dependency path is therefore marked in Irish, similar to the situation in Kikuyu examined earlier, but only in the case of a filler-gap dependency and not a resumptive pronoun, as these data from McCloskey (1979, 2002) demonstrate:

(102) a. *an t-úrscéal [aL mheas mé [aL thuig mé ___]]*
the novel *aL* thought I *aL* understood I
'the novel that I thought I understood'

b. *fir$_i$ [an shíl Aturnae an Stáit [go rabh siad$_i$ díleas do'n Rí]]*
men *aN* thought Attorney the State *go* were they loyal to.the King
'men that the Attorney General thought (they) were loyal to the King'

Thus, the complementizer *aL* appears to have two functions. First, it relates a member of the DIS set to the within-clause grammatical function associated with the gap, the defining relation in a filler-gap dependency. Second, in its 'marking' role in higher clauses, it establishes a link between the DIS set in its clause with the one in its COMP. The latter applies in each intervening clause, resulting in the multiple marking that we see in (102a).

Asudeh (2012) captures these features of long-distance dependency constructions in Irish by means of a lexical entry like the one in (103) for the complementizer *aL*, which he analyses as a non-projecting word.[19]

(103) aL $\widehat{\text{C}}$ $(\uparrow \text{COMPFORM}) = \text{AL}$
$(\uparrow \text{DIS}) = (\uparrow \underset{(\rightarrow \text{DIS}) = (\uparrow \text{DIS})}{\text{COMP}^*}\ \text{GF})$

The second constraint in the lexical entry in (103) equates the value of the DIS feature with some within-clause function GF. The off-path constraint annotated on the COMP attribute ensures that if the within-clause function GF is embedded in one or more COMPS, the DIS value of each intervening COMP f-structure is the same as the top-level DIS value. Asudeh's analysis of Irish long-distance dependency path-marking thus crucially involves a COMP-to-COMP relation established by the complementizer *aL*. As Asudeh notes, the analysis has commonalities with the successive cyclic movement analyses of Irish proposed by McCloskey (1990, 2002). On Asudeh's analysis, however, there is no movement involved; rather, a successive cyclic *dependency* is introduced.

Combined with the phrase structure rule in (101), the lexical entry in (103) enables us to formulate an analysis of a simple filler-gap dependency including the complementizer *aL* in Irish:

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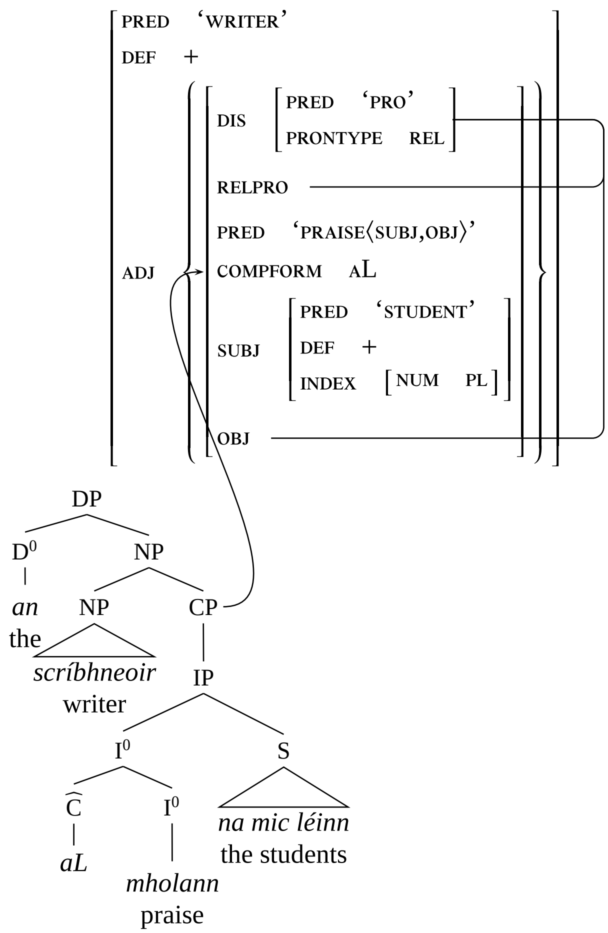
[18] McCloskey (2002) identifies three other multi-clause complementizer patterns which he refers to as *mixed chains*; see McCloskey (2002) and Asudeh (2012) for discussion of these patterns.

[19] We follow Asudeh (2012) in making the simplifying assumption that the DIS attribute in Irish has a single f-structure as its value, rather than a set.

(104) *an scríbhneoir aL mholann na mic léinn* ___
the writer *aL* praise the students
'the writer whom the students praise'



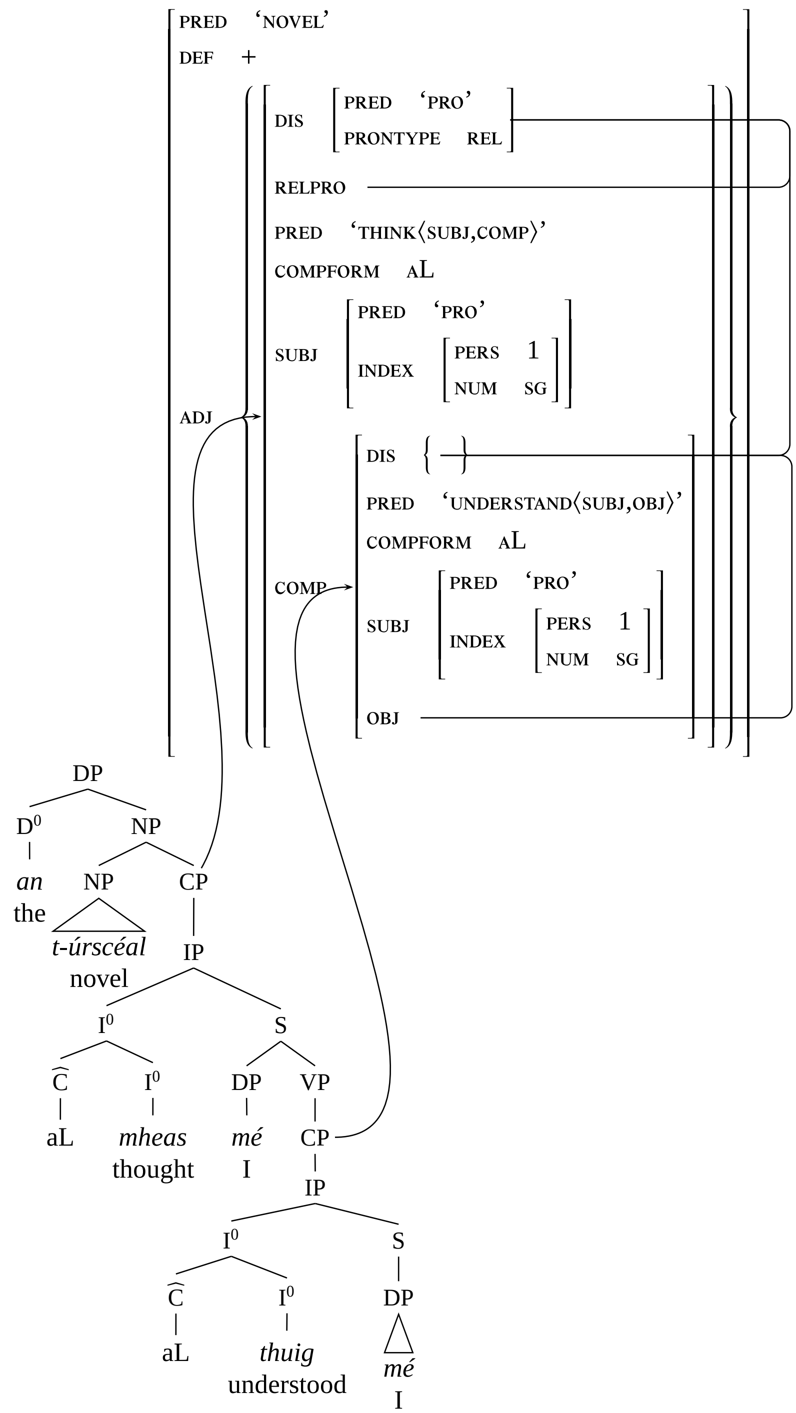
The specifier position of CP is unfilled in (104), and the DIS set member PRED 'PRO' is introduced by the phrase structure rule in (101). The dependency established between this member of DIS and a within-clause function (in this case, OBJ) is consistent with the lexical entry in (103).

The off-path constraint in (103) further requires a member of the DIS set in each intervening COMP to be identified with a member of the DIS set in the f-structure of the mother node, a constituent which includes the complementizer *aL*.[20] This takes care of the 'path marking' function of *aL* in intervening clauses.

[20] In order to ensure successive cyclic marking, the possibility of the complementizer *go* appearing in any intervening COMP has to be ruled out by including ¬ (↑ DIS) in the lexical entry for *go* (Asudeh 2012, page 173).

(105) *an t-úrscéal [aL mheas mé [aL thuig mé ___]]*
the novel *aL* thought I *aL* understood I

‘the novel that I thought I understood’



The final piece of the puzzle is semantic and concerns how the head is understood to be modified by the relative clause(s). We discuss the semantic analysis of relative clauses in Section 6.

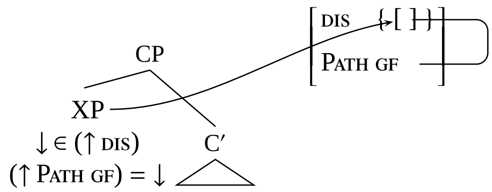
4. TRACES AND EMPTY CATEGORIES

The theory of the constituent structure properties of long-distance dependencies in LFG has undergone a major revision since the inception of the theory. Kaplan and Bresnan (1982) originally proposed to treat long-distance dependencies in terms of a relation between two positions in the constituent structure tree, one corresponding to the displaced constituent and the other to an unpronounced *gap* or *trace* within the clause. On this view, the f-structure role of a displaced constituent in a long-distance dependency is determined by the c-structure position of its corresponding gap. This theory was further developed in work by Zaenen (1980, 1983). Subsequently, however, work by Kaplan et al. (1987) and Kaplan and Zaenen (1989b) showed that constraints on long-distance dependencies are in fact primarily functional in nature and are best characterized in f-structure, not c-structure, terms. Kaplan et al. (1987) and Kaplan and Zaenen (1989b) first proposed functional uncertainty as a way of stating constraints on long-distance dependencies, and we have adopted this analysis in the foregoing discussion.

4.1. Outside-In or Inside-Out?

Any analysis of long-distance dependencies must capture the duality of the displaced phrase's functional role in the sentence: not only is it displaced, it also has a within-clause function. We refer to the top of the long-distance dependency (the displaced phrase in English) as the filler and its bottom as the gap. Functional uncertainty, as we have seen, enables us to state a relation between the filler and the gap in terms of a path through f-structure which may be subject to certain constraints. The standard approach is to use *outside-in functional uncertainty* to define a path from filler to gap, which can be characterized in general terms by annotations on the filler, as we have done in the foregoing. The constraints in (106) define a relation between the filler and its within-clause grammatical role GF in terms of an appropriately-constrained long-distance path PATH:

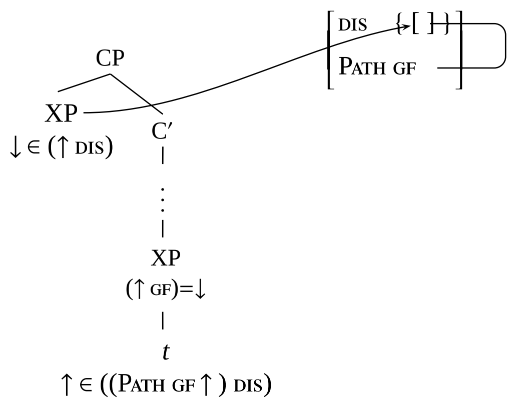
(106) Outside-in specification of the filler-gap dependency:



In fact, however, an outside-in expression annotated on the filler is not the only possible direction in which a filler-gap dependency can be licensed. While in this book we consistently adopt an outside-in functional uncertainty analysis, in line with the vast majority of work on long-distance dependencies in LFG, it is also possible to use inside-out functional uncertainty (Chapter 6, Section 1.3) in constraining the filler-gap relationship.

One of the issues with adopting an inside-out functional uncertainty approach to long-distance dependencies is the question of what precisely the inside-out expression should be associated with. One possibility is to assume the existence of an unpronounced c-structure element, a trace or gap (represented as *t* in 107), with which the inside-out constraint can be associated. This possibility is illustrated in (107):

(107) Inside-out specification of the filler-gap relation:



An alternative possibility, following analyses such as Bouma et al. (2001) and Ginzburg and Sag (2000) in the HPSG framework, is to treat the constraint as an optional lexical specification associated with all predicates, allowing any of the dependents of the predicate to participate in a long-distance dependency (recall that GF ranges over arguments and adjuncts of a predicate):

(108) Optional inside-out constraint specifying a potential filler-gap dependency involving a dependent of the predicate:

$((\uparrow \textsc{gf}) \in ((\textsc{Path}\uparrow)\ \textsc{dis}))$

This approach faces complications in languages in which more than one dependent of the same predicate can participate in a long-distance dependency, as in Russian examples such as (73b), repeated in (109); such examples would require multiple inside-out constraints associated with each predicate:

(109) *Kogda kto udaril Borisa?*
when who hit Boris
'Who hit Boris when?'

In fact, most LFG analyses which use inside-out functional uncertainty to constrain filler-gap dependencies assume the existence of traces. The general question of whether traces should be posited in LFG continues to be the subject of debate, and we return to this issue in the next section.

Falk (2006), in his work on subjecthood (see Chapter 2, Sections 1.5 and 1.11), argues against assuming a uniform approach to the type of functional uncertainty involved in long-distance dependencies. Recall that Falk (2006) proposes a more fine-grained approach to subjecthood, defining two separate functions — PIVOT and $\widehat{\text{GF}}$ — to replace SUBJ. PIVOT is an overlay function responsible for connecting its clause to other clauses in a sentence. As such, Falk (2006, pages 110) proposes the Pivot Condition: "a path inward through f-structure into another predicate-argument domain or sideways into a coordinate f-structure must terminate in the function PIVOT", consistent with PIVOT constituting the link between clauses. This condition requires us to specialize the grammatical function in the outside-in filler-gap constraint in (106) so that it terminates in the PIVOT function:

(110) Outside-in constraint specifying the within-clause role of a displaced constituent as PIVOT according to Falk (2006):

$$(\uparrow\ \textsc{Path pivot}) = \downarrow$$

Falk (2006) considers outside-in functional uncertainty to be unmarked relative to inside-out functional uncertainty, and inside-out functional uncertainty to be ruled out in the case of long-distance dependencies involving the PIVOT function.

This requires a separate treatment of long-distance dependencies involving non-PIVOT functions. Falk therefore proposes that inside-out rather than outside-in functional uncertainty applies in the case of non-PIVOT long-distance dependencies, and that in such cases there is an empty category in the 'gap' position at c-structure, as in (107). In (111), the inside-out specification in (107) is specialized to non-PIVOT functions:

(111) Inside-out constraint associated with an non-PIVOT trace in a filler-gap dependency according to Falk (2006):

$$\uparrow \in ((\textsc{gf}^*\ [\textsc{gf}-\ \textsc{pivot}]\ \uparrow\ )\ \textsc{dis})$$

The posited difference in the direction of functional uncertainty licensing depending on whether the terminating function is PIVOT or non-PIVOT accounts for an important typological distinction, Falk (2006) argues. The relative markedness of inside-out compared to outside-in functional uncertainty "suggests that languages with only one of the two formal constructions will normally have only the unmarked [PIVOT-only] construction" involving outside-in functional uncertainty (Falk 2006, page 115). As Falk observes, this is consistent with the findings of Keenan and Comrie (1977), among others: if a language is able to form long-distance dependencies involving only one type of function, that function is PIVOT/SUBJ. We do not adopt Falk's (2006) approach to functional uncertainty and long-distance dependencies here, but note that it captures this important typological distinction.

4.2. Evidence for Traces

Under a functional uncertainty approach, the role of constituent structure in constraining long-distance dependencies is considerably diminished, and it is reasonable to reevaluate the role of constituent structure and to reexamine evidence for gaps or traces. Indeed, Kaplan and Zaenen (1989b) present a set of arguments against the existence of traces (see also Sag and Fodor 1994), showing that many arguments that have been made in support of traces are flawed.

4.2.1. Weak Crossover

However, these works do not address one argument for the presence of traces: the phenomenon of *weak crossover*, originally discussed by Wasow (1979) and illustrated in (112):

(112) **Who*$_i$ *does his*$_i$ *mother like ___?*
(cf. *Whose*$_i$ *mother likes him*$_i$*?*)

The name *crossover* comes from early transformational analyses of examples like (112), which assumed that a violation ensues when a question phrase like *who* "crosses over" a coindexed pronoun in moving to the front of the sentence: in (112), *who* crosses over the coindexed pronoun *his*. Bresnan (1995, 1998, 2001c) and Bresnan et al. (2016) propose a theory of prominence for anaphoric binding that accounts for examples like (112) by assuming the presence of a trace in the object position of *like*.

As Bresnan demonstrates, languages vary in imposing different types of prominence requirements on the binding relation between a question phrase and the pronouns it binds. Three prominence dimensions are relevant: the functional hierarchy (on which, for example, SUBJ outranks OBJ); the thematic hierarchy (on which AGENT outranks THEME); and linear order (f-preceding elements outrank the elements they f-precede). Bresnan et al. (2016) propose that in English, a question phrase must outrank any pronouns it binds on *either* the grammatical function hierarchy (Syntactic Prominence) *or* the linear precedence hierarchy (Linear Prominence), so that satisfaction of either type of prominence requirement is sufficient. The two relevant dimensions of prominence are summarized by Dalrymple et al. (2007) thus:

(113) Prominence requirements (based on Bresnan et al. 2016):

Syntactic Prominence (A unit containing) the pronoun may not be higher than (a unit containing) the operator on the grammatical function hierarchy: SUBJ > OBJ > COMP > ...

Linear Prominence The pronoun must not f-precede the operator.

In (112), the question phrase *who* fills the OBJ role, and the pronoun *his* is contained in the SUBJ. Thus, the pronoun outranks the question phrase in Syntactic Prominence, and the condition in (113a) is not met.

In examining whether the Linear Prominence condition (113b) holds, we must determine whether the question phrase *who* f-precedes the pronoun *his*. Bresnan et al. assume that constituent question formation in English involves the presence of traces, so that the f-structure for *who* in (112) corresponds to two c-structure positions: the initial position in which *who* appears, and the gap position following *like*. They rely on the definition of f-precedence given in (187) of Chapter 6, Section 11.4, repeated here:

(114) F-precedence, alternate definition (Bresnan et al. 2016, page 213):

f f-precedes g if the rightmost node in $\phi^{-1}(f)$ precedes the rightmost node in $\phi^{-1}(g)$.

In (112), the rightmost node corresponding to the f-structure for *who* is the trace, which does not precede the pronoun; therefore, the question phrase does not f-precede the pronoun according to the definition given in (114), and the Linear Prominence requirement is not satisfied. Since neither the Syntactic Prominence condition nor the Linear Prominence condition is met, (112) is correctly predicted to be ungrammatical.

Bresnan (1995, 1998), Berman (2003), and Bresnan et al. (2016) examine weak crossover violations in German, proposing that German imposes the same prominence conditions on binding by question phrases as English, and ascribing differences between the two languages to variation in the presence of traces in the two languages. The German equivalent of (113) is fully grammatical:

(115) *Wen mag seine Mutter?*
who-ACC likes his mother-NOM
'Who$_i$ does his$_i$ mother like?'

Berman (2003) and Bresnan et al. (2016) argue that no trace is present in German examples like (115), since the grammatical function of the fronted argument is determined locally, by reference to its casemarking, rather than by its position. Since no trace appears in this clause, the f-structure of the question phrase f-precedes the f-structure of the pronoun; the Linear Prominence condition is thereby satisfied, accounting for the acceptability of the example.

In contrast, they argue that traces must be assumed in extractions from subordinate clauses in German, since case information is insufficient to identify the grammatical function of the extracted element in the embedded clause. Bresnan et al. (2016) do not explicitly represent the trace in (116), since its position is uncertain, though it appears somewhere within the subordinate clause.

(116) **Wen meinte seine Mutter, [habe sie getröstet]?*
who-ACC said his mother has she consoled
'Who$_i$ did his$_i$ mother say that she consoled?'

Here, the Linear Prominence condition is not satisfied. The f-structure for *wen* 'who' also corresponds to the position of the trace in the subordinate clause. The subordinate clause trace position is rightmost, and is therefore the one that is relevant in evaluating f-precedence requirements. The trace in the subordinate clause does not precede the matrix clause pronoun, and so the Linear Prominence condition is not met. Since the Syntactic Prominence condition is also not met, the sentence is correctly predicted to be ungrammatical with the indicated indexing. Thus, according to Bresnan's proposal, the availability and distribution of empty c-structure categories provide a new view of weak crossover phenomena in German, Hindi, Malayalam, and Palauan.

However, there are indications that an account of weak crossover may be available even if traces are not assumed. Dalrymple et al. (2001, 2007) explore a different definition of the Linear Prominence condition, based on unpublished work by Sag (1998). In this approach, the f-precedence relation that is considered in evaluating the Linear Prominence condition holds between the pronoun and an f-structure that *f-commands*[21] the pronoun and contains the question phrase.

The approach proposed by Dalrymple et al. (2001) is defined in terms of co-dependenthood; co-dependents are defined as in (117):[22]

(117) Co-Dependents:

the arguments and adjuncts of a single predicate

Dalrymple et al. provide revised prominence requirements which make reference to co-dependents and, crucially, define Linear Prominence in terms of the relationship between the pronoun and CoargOp (the f-structure which *contains* the operator rather than just the f-structure of the operator):

(118) Let CoargOp and CoargPro be co-dependent f-structures such that CoargOp contains O and CoargPro contains P. Then:

Syntactic Prominence An operator O is more prominent than a pronoun P if and only if CoargOp is at least as high as CoargPro on the functional hierarchy.

Linear Prominence An operator O is more prominent than a pronoun P if and only if CoargOp f-precedes P.

The result is that it is the head of the overt phrase containing the gap (for instance, the preposition in the case of an oblique) which determines Linear Prominence under Dalrymple et al.'s analysis. In (119), CoargOp (the f-structure which contains the question phrase operator) is the COMP f-structure, as labeled:[23]

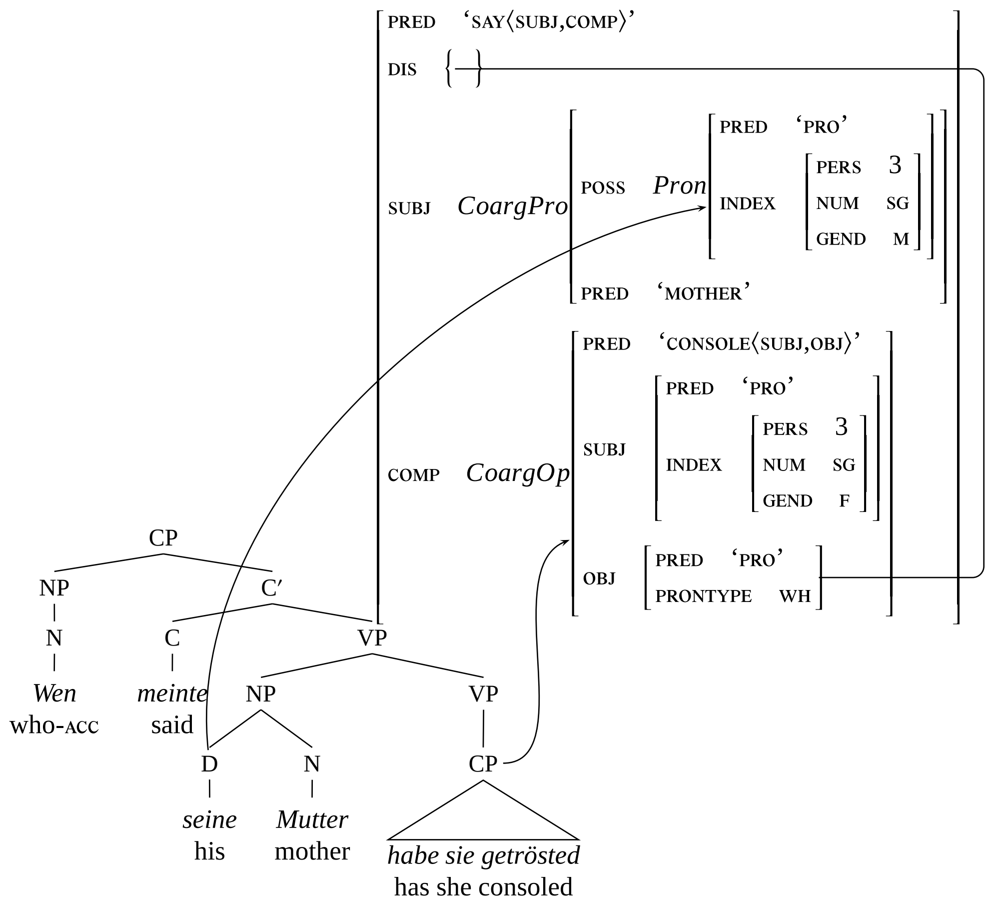
(119) **Wen meinte seine Mutter, [habe sie getröstet]?*
who-ACC said his mother has she consoled

[21]F-command is defined in Chapter 6, Section 9.1. Intuitively, an f-structure f-commands its "sister" f-structures, those that are arguments of the same f-structure, and f-structures contained in its sisters.

[22]Dalrymple et al. (2001) use the term 'coargument' for this concept, but since the term ranges over adjuncts as well as arguments, we use the term 'co-dependent'.

[23]For clarity, in these examples CoargOp f-structures are shown as the value of the 'gap' grammatical function at f-structure rather than as a member of the DIS set.

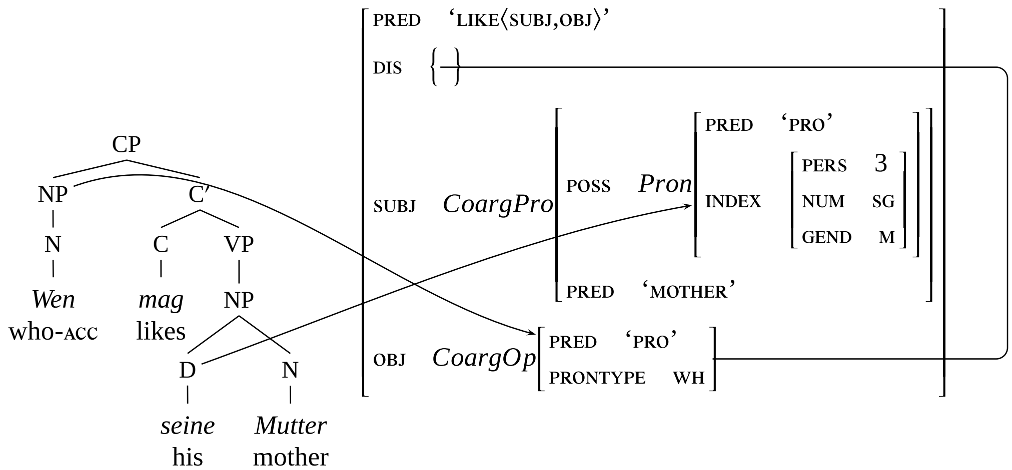
‘Who$_i$ did his$_i$ mother say that she consoled?’



According to either definition of f-precedence given in Chapter 6, Section 11.4, the CoargOp’s f-structure does not f-precede the pronoun’s f-structure, and the example is ruled out. In contrast, in (120) CoargOp is the f-structure for *wen* ‘who’:

(120) *Wen* *mag* *seine* *Mutter?*
who-ACC likes his mother-NOM

‘Who$_i$ does his$_i$ mother like?’



The CoargOp’s f-structure f-precedes the pronoun’s f-structure, and the Linear Prominence condition is satisfied. The ungrammaticality of the corresponding English example in (112) is accounted for by the Syntactic Prominence condition, as described above; thus, this alternative account of weak crossover violations differs from accounts presented by Berman (2003) and Bresnan et al. (2016) in assuming that in English, though not in German, the Syntactic Prominence condition must always be met. On this approach, weak crossover violations are accounted for without assuming traces.

Nadathur (2013) proposes a further refinement of the definition of Linear Prominence in a new LFG analysis of weak crossover based on Pickering and Barry’s (1991) Direct Association Hypothesis. Pickering and Barry provide psycholinguistic evidence that the relevant link in a long-distance dependency is not between the filler and the gap, but between the filler and the predicate (verb, preposition, or other category) that selects for the gap, which Nadathur refers to as its *anchor*. She provides the following definition of Linear Prominence:

(121) **Linear Prominence** (adapted from Nadathur 2013):

The anchor (of the operator) must f-precede the pronoun.

This differs from Dalrymple et al.’s (2001) approach in treating the element which subcategorizes for the operator, rather than a phrase containing the operator, as participating in the relevant structural relationship.

The primary contribution of this refinement to Dalrymple et al.’s (2001) approach to weak crossover is identified by Nadathur as a lesser reliance on Syntactic Prominence generally. For instance, on the definition of Linear Prominence given in (118b), there is no difference between SUBJ and OBJ f-structures in examples such as:

(122) a. **[Who$_i$]$_{\text{Op}}$ did [his$_i$]$_{\text{Pronoun}}$ mother [greet]$_{\text{Anchor}}$?*

b. *[Who$_i$]$_{\text{Op}}$ [greeted]$_{\text{Anchor}}$ [his$_i$]$_{\text{Pronoun}}$ mother?*

(122a) is ruled out because it violates Syntactic Prominence under Dalrymple et al.'s (2001) analysis. By contrast, the definition of Linear Prominence provided in (121) is by itself sufficient to account for the difference in grammaticality between (122a) and (122b). This represents a considerable simplification. Nadathur (2013) shows that the anchor approach to Linear Prominence may also fare better than the alternatives with respect to some Hindi and German weak crossover data.

4.2.2. Nested Dependencies

In many but not all languages, multiple long-distance dependencies must not cross, but rather must be nested (Kuno and Robinson 1972, page 477):

(123) a. Nested dependency:

?This is the knife that this salami is easy to cut ___ with ___.

b. Crossed dependency:

**This is the salami that my knife is easy to cut ___ with ___.*

These facts about crossed dependencies have been taken as evidence for traces, the argument being that it is the position of the traces that is responsible for the attested ungrammaticality. However, non-trace analyses of this phenomenon are also possible: Dalrymple and King (2013) offer a non-trace approach.

Dalrymple and King (2013) reject an f-precedence analysis on the basis that no definition of f-precedence makes it possible to single out unacceptable crossing dependencies from other types of configurations involving multiple long-distance dependencies. Instead, they offer an analysis framed in terms of OPERATOR SUPERIORITY, where each filler is identified as an operator. Dalrymple and King characterize nested dependencies as constructions in which the first filler is superior to the second filler, and the second gap is superior to the first gap. Their definition of superiority incorporates a particular version of f-command (Chapter 6, Section 9.1), which holds between operators each of which is in an DIS set:

(124) F-command between operators:

Operator f DIS-commands operator g if and only if:
$\neg(f\ \text{GF}^*) = g$ (f does not contain g) and
$g \in ((\text{DIS} \in f)\ \text{GF}^*\ \text{DIS})$ (an f-structure whose value for the attribute DIS contains f also contains an f-structure whose value for the attribute DIS contains g).

For example, f DIS-commands g in the following f-structure:

(125) $\left[\begin{array}{ll} \text{DIS} & \{\ f[\ ]\ \} \\ ... & \left[\begin{array}{ll} \text{DIS} & \{\ g[\ ]\ \} \end{array}\right] \end{array}\right]$

Dalrymple and King provide an initial formulation of the constraint which disallows crossed dependencies:

(126) If two dependencies f-command each other, then if operator O1 DIS-commands operator O2, then T2 must be SUPERIOR to T1.

The rule in (126) appeals to the definition of DIS-superiority given in (124). What remains to be defined is the superiority relation that holds between gaps (T1, T2). For this, Dalrymple and King (2013) rely on the Direct Association Hypothesis (Pickering and Barry 1991; Pickering 1993) and the notion of anchor discussed in the previous section. On this view, the relevant superiority relation is not between traces T1 and T2, but between Anchor1 (the predicate which selects for T1) and Anchor2 (the predicate which selects for T2). Dalrymple and King (2013) define the final version of the constraint on nested dependencies as in (127).

(127) If two dependencies f-command each other, then if operator O1 DIS-commands operator O2, then the anchor for O1 (Anchor1) must not f-precede the anchor for O2 (Anchor2).

The difference between nested and crossed dependencies can therefore be accounted for without positing traces; in general, work relying on the Direct Association Hypothesis appeals to the position of anchors rather than the position of traces in precedence-related constraints on filler-gap dependencies.

(128) satisfies the constraint in (127): O1 DIS-commands O2 and Anchor1 does not f-precede Anchor2:

(128) Nested dependencies:

Which violin is this sonata O2 *tough to* *play* *on?*
O1 Anchor2 Anchor1

By contrast, (129) does not satisfy the constraint in (127) because Anchor1 f-precedes Anchor2:

(129) Crossed dependencies:

**Which sonata is this violin* O2 *tough to* *play* *on?*
O1 Anchor1 Anchor2

Dalrymple and King (2013) also review previous work which shows that, while crossing dependencies result in ungrammaticality in English, for example, this is not true crosslinguistically. Crossed dependencies are permitted in Norwegian and merely dispreferred in Swedish (Maling and Zaenen 1982). Thus, the constraint in (127) does not apply across all languages. Dalrymple and King (2013) consider how this variation can be accounted for within the LFG framework without recourse to traces.

4.2.3. 'Wanna' Contraction

Another construction which has been argued to support the existence of traces involves contraction. The claim is that the presence of a trace or empty category blocks the possibility of contraction of, for example, *want to* to *wanna* (Lakoff 1970; Pullum 1997):

(130) a. *Who do you want to/wanna see ___?*

b. *Who do you want ___ to/*wanna see Maisie?*

Falk (2007) presents a contraction-based account of this pattern, set within the context of the "last resort" status of empty categories, which Bresnan et al. (2016) view as a consequence of the Principle of Economy of Expression (Chapter 4, Section 5). On Falk's view, "empty categories have no semantic content, so their only possible role is in licensing grammatical f-structures". Only when no alternative exists for licensing an f-structure is an empty category's presence justified. Falk argues that this is the case in non-SUBJ (under Falk's approach, non-PIVOT) long-distance dependencies such as (130b), which, on Falk's analysis, are defined in terms of inside-out functional uncertainty. The consequence of assuming inside-out functional uncertainty in the non-SUBJ (non-PIVOT) cases is that a node must be associated with an inside-out equation, and this node, being devoid of lexical content, must be an empty category. Falk claims that "the last resort nature of empty categories explains the empirical evidence of their rather limited distribution". The fact that not all speakers judge *wanna*-contraction in examples like (130b) to be ungrammatical, Falk (2007) ascribes to a difference in how speakers view adjacency. If phonological adjacency is all that counts for a speaker, then contraction is possible (the so-called 'liberal' dialect). However, if a speaker judges adjacency to be determined at the level of phrasal structure, where an NP node occupied by an empty category intervenes between the verb and infinitive marker *to*, then contraction is blocked. In this way, Falk accounts for variation in judgement without abandoning his empty category analysis of non-PIVOT/non-SUBJ long-distance dependency constructions.

Future work will reveal more about how binding by operators is constrained, the implications of *wanna*-type contractions, and whether incontrovertible evidence exists for traces, gaps, or empty phrase structure categories. In the absence of such evidence, a simpler and more parsimonious theory of long-distance dependencies results if traces are not allowed.

5. MULTIPLE-GAP CONSTRUCTIONS

In multiple-gap constructions, a single filler is related to multiple gaps:

(131) a. *[Which articles]$_i$ did John file ___$_i$ without reading ___$_i$?*

b. *Who$_i$ did you tell ___$_i$ that you would visit ___$_i$?*

Multiple-gap constructions are distinct from 'across-the-board' constructions; in the former (132a) but not the latter (132b), a pronoun can appear in the position of one of the gaps:

(132) a. *[Which articles]$_i$ did John file ___$_i$ without reading ___$_i$/them$_i$?* (multiple gap construction)

b. *These are [the articles]$_i$ that [John filed ___$_i$] and [everyone else read ___$_i$/*them$_i$].* ('across-the-board' construction)

Multiple-gap constructions have been referred to in the literature as involving 'parasitic gaps', the idea being that there is one 'main' gap, and that additional gaps are licensed by virtue of being parasitic on the 'main' gap. However, Falk (2011) points out that the term 'parasitic gap' in fact is more appropriately applied to only a subset of multiple-gap constructions. For example, the second gap in (132a) is parasitic on the first gap: as shown in (133), a sentence with a full noun phrase in the object position of *reading* is grammatical, but a similar sentence with a full noun phrase in the object position of *file* is not grammatical. In contrast, neither gap is parasitic on the other in the multiple-gap construction in (131b), since either of the gaps can alternate with a pronoun or full noun phrase, as shown in (134):

(133) a. * *[What/Which articles]$_i$ did John file the book without reading ___$_i$?*

b. *[What/Which articles] did John file ___$_i$ without reading the book?*

(134) a. *[Who/Which friend]$_i$ did you tell ___$_i$ that you would visit your brother?*

b. *[Who/Which friend]$_i$ did you tell your brother that you would visit ___$_i$?*

For this reason, Falk advocates the term 'multiple-gap construction' to refer to both types of example, and we adopt Falk's terminology here. Falk (2011) provides the following f-structure for a multiple-gap construction.

(135) *Who$_i$ did you tell ___$_i$ that you would visit ___$_i$?*

$$\begin{bmatrix}
\text{DIS} & \begin{bmatrix}\text{PRED} & \text{‘PRO’}\\ \text{PRONTYPE} & \text{WH}\end{bmatrix}\\
\text{Q} & \\
\text{PRED} & \text{‘TELL}\langle\text{SUBJ,OBJ,COMP}\rangle\text{’}\\
\text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{‘PRO’}\\ \text{INDEX} & \begin{bmatrix}\text{PERS} & 2\\ \text{NUM} & \text{SG}\end{bmatrix}\end{bmatrix}\\
\text{OBJ} & \\
\text{COMP} & \begin{bmatrix}\text{PRED} & \text{‘VISIT}\langle\text{SUBJ,OBJ}\rangle\text{’}\\ \text{COMPFORM} & \text{THAT}\\ \text{SUBJ} & \begin{bmatrix}\text{PRED} & \text{‘PRO’}\\ \text{INDEX} & \begin{bmatrix}\text{PERS} & 2\\ \text{NUM} & \text{SG}\end{bmatrix}\end{bmatrix}\\ \text{OBJ} & \end{bmatrix}
\end{bmatrix}$$

Two main issues are the subject of continuing investigation in LFG analyses of such multiple-gap constructions. First, there is the question of how the relation is established between a single filler and multiple gaps. As depicted in (106), it is often assumed that filler-gap dependencies are constrained via an outside-in specification on the filler:

(136) Annotation on the filler specifying a filler-gap dependency (see 106):

$(\uparrow \text{Path gf}) = \downarrow$

As Falk (2011) notes, this outside-in annotation establishes a dependency between a filler and a single gap. Additional annotations of a similar form would be needed to establish a similar dependency involving multiple gaps. This issue does not arise when the dependency is established via an inside-out specification, as in (107), since there is no obstacle to a single filler being the target of multiple filler-gap specifications by multiple gaps.

A second challenge is accounting for the constraints which apply to multiple-gap constructions. Early work, including Engdahl (1983), assumed that the relevant constraints were best formulated in terms of c-command: specifically, that in a multiple-gap construction one gap cannot c-command the other. This explains the ungrammaticality of (137), in which the second gap is c-commanded by the first:

(137) **Who$_i$ did you say ___$_i$ convinced you [___$_i$ should pass the course]?*
(cf. *You said David$_i$ convinced you (that) [he$_i$ should pass the course].*)

However, Engdahl (1983) points out that the c-command requirement does not account for all of the data: there are sentences (in whose non-gap equivalent a reflexive can appear) that do not support multiple gaps, regardless of the fact that no c-command relation holds between the two gaps:

(138) **Who$_i$ did you talk to ___$_i$ about ___$_i$?*
(cf. *Who$_i$ did you talk to ___$_i$ about himself$_i$?*)

Furthermore, grammaticality patterns differ when the higher gap is a c-commanding non-subject (Chomsky 1986), indicating that the constraint is properly formulated in terms of grammatical functions rather than c-command:

(139) *Who$_i$ did you tell ___$_i$ [that you would visit ___$_i$]?*

Falk (2011) therefore proposes that the appropriate constraint is best expressed in terms of f-structure relations: a non-subject gap cannot participate in a multiple gap construction with an f-commanding subject. Recall that Falk (2006) proposes that long-distance dependencies involving the PIVOT/SUBJ function are licensed by outside-in functional uncertainty, while non-SUBJ dependencies are licensed by inside-out functional uncertainty. Falk notes that the constraint as he formulates it has a welcome consequence: it rules out inside-out licensing of any long-distance relationship in which the filler has the grammatical function SUBJ, not just in the case of multiple-gap constructions but in all constructions involving a gap.

6. RELATIVE CLAUSES AND SEMANTIC COMPOSITION

6.1. Semantics of Relative Clauses

Like the adjectival modifiers studied in Chapter 13, a relative clause is a noun modifier, producing a modified meaning of type $\langle e \rightarrow t \rangle$ when combined with a noun meaning of the same type. Recall that a simple noun like *man* has a meaning like the following, which we can think of as picking out the set of individuals that are men:

(140) *man*

$\lambda x.\mathit{man}(x)$

The meaning of a noun modified by a relative clause, like *man who Chris saw*, is of the same type. It represents the set of individuals that are men (the meaning contribution of *man*), that are people (the meaning contribution of *who*), and that were seen by Chris (the meaning contribution of *Chris saw*):

(141) *man who Chris saw*

$\lambda x.\mathit{person}(x) \wedge \mathit{see}(\mathit{Chris}, x) \wedge \mathit{man}(x)$

The meaning contribution of the relative pronoun *who* is redundant here, since the fact that an individual is a man entails that he is a person. In some cases, however, the information contributed by the relative pronoun is not redundant: consider an example like *pitcher who/which Chris saw*.

Relative clauses with possessive relative pronouns are interpreted similarly. We assign the interpretation in (142) to the phrase *man whose pen Chris used*. We treat the possessive determiner as definite, following Partee and Borschev (1998), and we use the predicate name *poss* to represent the generalized "possession" relation holding between the possessor and the possessed entity.

(142) *man whose pen Chris used*

$$\lambda x.\mathit{the}(y, \mathit{poss}(x, y) \wedge \mathit{pen}(y), \mathit{use}(\mathit{Chris}, y)) \wedge \mathit{man}(x)$$

6.2. Relative Clauses and Meaning Assembly

We assume the following f-structure, semantic structure, and meaning constructor for the phrase *man who Chris saw*:

(143) *man who Chris saw*

$$m\left[\begin{array}{ll} \text{PRED} & \text{`MAN'} \\ \text{ADJ} & \left\{ s\left[\begin{array}{ll} \text{DIS} & \left\{ w\left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\\ \text{PRONTYPE} & \text{REL}\end{array}\right]\right\} \\ \text{RELPRO} & \\ \text{PRED} & \text{`SEE}\langle\text{SUBJ,OBJ}\rangle\text{'} \\ \text{SUBJ} & c\left[\begin{array}{ll}\text{PRED} & \text{`CHRIS'}\end{array}\right] \\ \text{OBJ} & \end{array}\right] \right\} \end{array}\right] \dashrightarrow m_\sigma\left[\begin{array}{ll}\text{VAR} & v[\;]\\ \text{RESTR} & r[\;]\end{array}\right]$$

$$\lambda x.\mathit{person}(x) \wedge \mathit{see}(\mathit{Chris}, x) \wedge \mathit{man}(x) : v \multimap r$$

As described in Chapter 13, noun modifiers such as the relative clause *who Chris saw* combine with the noun meanings that they modify to produce a new, modified meaning of the same type. Thus, the implicational meaning constructor in (143) is similar to the meaning constructor for a proper noun like *man*, but with a modified meaning reflecting the meaning of the relative clause:

(144) *man*

$$m\left[\begin{array}{ll}\text{PRED} & \text{`MAN'}\end{array}\right] \dashrightarrow m_\sigma\left[\begin{array}{ll}\text{VAR} & v[\;]\\ \text{RESTR} & r[\;]\end{array}\right]$$

$$\lambda x.\mathit{man}(x) : v \multimap r$$

In the analysis of (143), we assume the relative clause rule given in (33) of this chapter, augmented with the meaning constructor labeled **[rel]**:

(145) $$\text{CP} \longrightarrow \begin{pmatrix} \text{RelP} \\ \downarrow\in(\uparrow \textsc{dis}) \\ (\uparrow \text{ RTopicPath}) = \downarrow \\ (\uparrow \textsc{relpro}) = (\downarrow \text{RelPath}) \\ (\uparrow \textsc{relpro prontype}) =_c \textsc{rel} \end{pmatrix} \begin{pmatrix} \text{C}' \\ \uparrow=\downarrow \\ \textbf{[rel]} \end{pmatrix}$$

As discussed in Chapter 8, Section 6, there are cases in which meaning contributions are associated with phrase structure configurations rather than lexical items. Relative clause formation in English is one such case: the meaning constructor **[rel]**, which combines the relative clause meaning with the meaning of the modified noun, is associated with the relative clause CP rule. Here is the definition of **[rel]**:

(146) **[rel]** $$\lambda P.\lambda Q.\lambda x.P(x) \wedge Q(x) : \\ [(\uparrow \textsc{relpro})_\sigma \multimap \uparrow_\sigma] \multimap \\ [[((\textsc{adj} \in \uparrow)_\sigma \textsc{ var}) \multimap ((\textsc{adj} \in \uparrow)_\sigma \textsc{ restr})] \multimap \\ [((\textsc{adj} \in \uparrow)_\sigma \textsc{ var}) \multimap ((\textsc{adj} \in \uparrow)_\sigma \textsc{ restr})]]$$

Instantiating the $\uparrow$ metavariables in (146) according to the f-structure labels in (143), we obtain this meaning constructor premise:

(147) **[rel]** $\lambda P.\lambda Q.\lambda x.P(x) \wedge Q(x) : [w_\sigma \multimap s_\sigma] \multimap [[v \multimap r] \multimap [v \multimap r]]$

This meaning constructor consumes the meaning resource of the relative clause $w_\sigma \multimap s_\sigma$ and the meaning resource of the modified noun $v \multimap r$ to produce a new noun resource, also associated with $v \multimap r$ but reflecting a modified meaning.

We must also provide a meaning for the relative pronoun *who*. We propose that *who* augments the relative clause meaning by providing the additional meaning that the entity involved is a person. This is the lexical entry for *who*:

(148) *who* $$(\uparrow \textsc{pred}) = \text{`}\textsc{pro}\text{'} \\ (\uparrow \textsc{prontype}) = \textsc{rel} \\ \lambda S.\lambda x.\mathit{person}(x) \wedge S(x) : \\ [\uparrow_\sigma \multimap (\textsc{relpro} \uparrow)_\sigma] \multimap [\uparrow_\sigma \multimap (\textsc{relpro} \uparrow)_\sigma]$$

Instantiating the $\uparrow$ metavariables in the meaning constructor in (148), we have the meaning constructor labeled **[who]** in (149). We also assume the standard meaning constructor for the name *Chris* as given in Chapter 8. Since the example we discuss does not involve anaphoric binding, we provide simple noncontextual meaning constructors. Thus, the following are the meaning constructor premises that are relevant in the analysis of *man who Chris saw*:

(149) Meaning constructor premises for *man who Chris saw*

$$
\begin{array}{lrcl}
\textbf{[man]} & \lambda x.man(x) & : & v \multimap r \\
\textbf{[who]} & \lambda S.\lambda x.person(x) \wedge S(x) & : & [w_\sigma \multimap s_\sigma] \multimap [w_\sigma \multimap s_\sigma] \\
\textbf{[see]} & \lambda x.\lambda y.see(x,y) & : & c_\sigma \multimap [w_\sigma \multimap s_\sigma] \\
\textbf{[Chris]} & Chris & : & c_\sigma \\
\textbf{[rel]} & \lambda P.\lambda Q.\lambda x.P(x) \wedge Q(x) & : & [w_\sigma \multimap s_\sigma] \multimap [[v \multimap r] \multimap [v \multimap r]]
\end{array}
$$

We begin by combining the premises labeled **[Chris]** and **[see]** to obtain the meaning constructor labeled **[Chris-see]**:

(150) **[Chris-see]** $\lambda y.see(Chris, y) : w_\sigma \multimap s_\sigma$

This provides the meaning resource required by the premise **[who]**. Combining **[Chris-see]** and **[who]**, we have the meaning constructor labeled **[who-Chris-see]**:

(151) **[who-Chris-see]** $\lambda x.person(x) \wedge see(Chris, x) : w_\sigma \multimap s_\sigma$

Next, we combine the premises **[who-Chris-see]** and **[rel]**, producing the premise **[who-Chris-see-rel]**:

(152) **[who-Chris-see-rel]** $\lambda Q.\lambda x.person(x) \wedge see(Chris, x) \wedge Q(x) :$
$[v \multimap r] \multimap [v \multimap r]$

As discussed in Chapter 13, this meaning constructor has the characteristic form of a modifier: it consumes the resource $[v \multimap r]$ and produces a new resource of the same form but with a modified meaning. Combining **[who-Chris-see-rel]** with **[man]**, we have, as desired:

(153) **[man]**, **[who-Chris-see-rel]** $\vdash$
$\lambda x.person(x) \wedge see(Chris, x) \wedge man(x) : v \multimap r$

We now expand our treatment of English relative clauses to encompass relative clauses with no relative pronoun, as in an example like *the man Chris saw*. An advantage of our analysis is that no additions or changes must be made to the lexical entries or meaning constructors provided so far. All that is necessary is to augment the c-structure rule given in (145) to provide the proper syntactic constraints when a relative pronoun is not present, using the ϵ notation introduced in Chapter 6, Section 10.4, as was done in the rule for Irish relative clauses in (101).

(154)
$$
\text{CP} \longrightarrow \left\{ \begin{array}{c|c}
\text{RelP} & \epsilon \\
\downarrow \in (\uparrow \textsc{dis}) & (\uparrow \textsc{relpro}) \in (\uparrow \textsc{dis}) \\
(\uparrow \text{ RTopicPath}) = \downarrow & (\uparrow \text{ RTopicPath}) = (\uparrow \textsc{relpro}) \\
(\uparrow \textsc{relpro}) = (\downarrow \text{RelPath}) & (\uparrow \textsc{relpro pred}) = \text{`}\textsc{pro}\text{'} \\
(\uparrow \textsc{relpro prontype}) =_c \textsc{rel} &
\end{array} \right\}
\quad
\begin{pmatrix} \text{C}' \\ \uparrow = \downarrow \\ \textbf{[rel]} \end{pmatrix}
$$

According to this rule, when no RelP phrase is present, the equations under ϵ must be satisfied. The annotations on the ϵ node provide a DIS attribute whose value contains the RELPRO f-structure; this f-structure also plays a role inside the clause defined by RelPath, and its value for the attribute PRED is 'PRO'. With these assumptions, the phrase *man Chris saw* has this f-structure, semantic structure, and meaning constructor:

(155) *man Chris saw*

$$
m\left[\begin{array}{ll}
\text{PRED} & \text{`MAN'}\\
\text{ADJ} & \left\{ s\left[\begin{array}{ll}
\text{DIS} & \left\{ w\left[\text{PRED}\ \ \text{`PRO'}\right] \right\}\\
\text{RELPRO} & \\
\text{PRED} & \text{`SEE}\langle\text{SUBJ},\text{OBJ}\rangle\text{'}\\
\text{SUBJ} & c\left[\text{PRED}\ \ \text{`CHRIS'}\right]\\
\text{OBJ} &
\end{array}\right]\right\}
\end{array}\right]
\qquad
m_\sigma\left[\begin{array}{ll}\text{VAR} & v[\ ]\\ \text{RESTR} & r[\ ]\end{array}\right]
$$

$\lambda x.see(Chris,x) \wedge man(x) : v \multimap r$

The meaning derivation proceeds straightforwardly from the premises in (156), which are contributed by the lexical items and the CP phrase structure rule figuring in the analysis of this phrase:

(156) Meaning constructor premises for *man Chris saw*

[man]	$\lambda x.man(x)$	:	$v \multimap r$
[see]	$\lambda x.\lambda y.see(x,y)$	:	$c_\sigma \multimap [w_\sigma \multimap s_\sigma]$
[Chris]	$Chris$	:	c_σ
[rel]	$\lambda P.\lambda Q.\lambda x.P(x) \wedge Q(x)$	:	$[w_\sigma \multimap s_\sigma] \multimap [[v \multimap r] \multimap [v \multimap r]]$

As above, we combine the premises labeled **[Chris]** and **[see]**, obtaining the premise labeled **[Chris-see]**:

(157) **[Chris-see]** $\lambda y.see(Chris,y) : w_\sigma \multimap s_\sigma$

We combine **[Chris-see]** with **[rel]** to obtain **[Chris-see-rel]**:

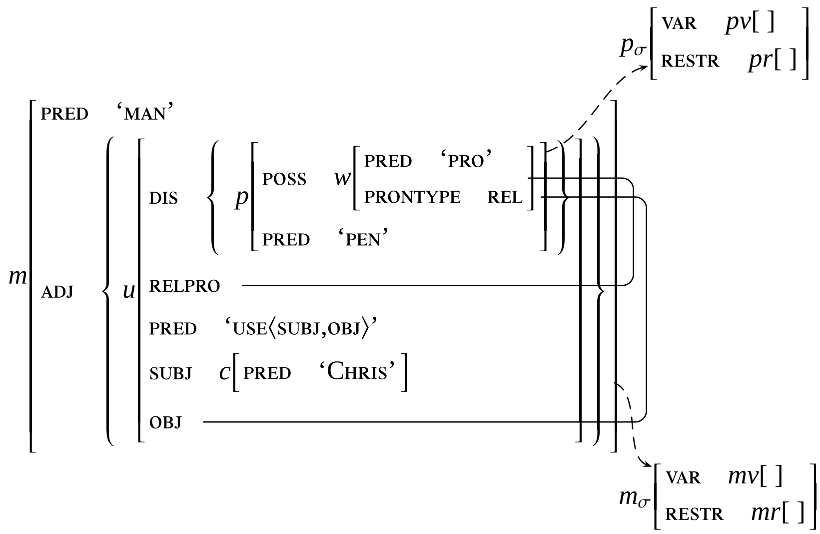
(158) **[Chris-see-rel]** $\lambda Q.\lambda x.see(Chris,x) \wedge Q(x) : [v \multimap r] \multimap [v \multimap r]$

Combining **[Chris-see-rel]** with **[man]**, we obtain the desired result:

(159) **[man]**, **[Chris-see-rel]** $\vdash$ $\lambda x.see(Chris,x) \wedge man(x) : v \multimap r$

Our final task is to examine relative clauses with possessive relative pronouns. The following are the f-structure, semantic structures, and meaning constructor for *man whose pen Chris used*:

(160) *man whose pen Chris used*



$$\lambda x.the(y, poss(x, y) \wedge pen(y), use(Chris, y)) \wedge man(x) : mv \multimap mr$$

We assume this lexical entry for the possessive relative pronoun *whose*:

(161) *whose* $(\uparrow \text{PRED}) = \text{`PRO'}$
$(\uparrow \text{PRONTYPE}) = \text{REL}$

$$\lambda P.\lambda Q.\lambda x.the(y, poss(x, y) \wedge P(y), Q(y)) : [((\text{POSS}\ \uparrow)_\sigma\ \text{VAR}) \multimap ((\text{POSS}\ \uparrow)_\sigma\ \text{RESTR})] \multimap [[(\text{POSS}\ \uparrow)_\sigma \multimap (\text{RELPRO}\ \uparrow)_\sigma] \multimap [\uparrow_\sigma \multimap (\text{RELPRO}\ \uparrow)_\sigma]]$$

In (161) we instantiate this meaning constructor according to the f-structure labels in (160), obtaining the meaning constructor labeled **[whose]** in (162). We also provide the standard meaning constructor for the common noun *pen*, labeled **[pen]**:

(162) Meaning constructor premises for *whose pen*

[pen] $\lambda x.pen(x) : pv \multimap pr$

[whose] $\lambda P.\lambda Q.\lambda x.the(y, poss(x, y) \wedge P(y), Q(y)) : [pv \multimap pr] \multimap [[p_\sigma \multimap u_\sigma] \multimap [w_\sigma \multimap u_\sigma]]$

The meaning constructor of *whose* is similar to the meaning constructor for *every*, discussed in Chapter 8: *every* requires a meaning for its restriction and a meaning for its scope to produce a meaning for the sentence in which it appears. The possessive determiner *whose* also requires a meaning for its restriction; this requirement is represented on the right-hand side of the meaning constructor labeled **[whose]** by a requirement for a resource $pv \multimap pr$, corresponding to the meaning *P*, exactly as for a determiner like *every*. This requirement is satisfied by the meaning constructor **[pen]**. Combining **[whose]** and **[pen]**, we have the meaning constructor **[wh-pen]**:

(163) **[wh-pen]** $\lambda Q.\lambda x.\mathit{the}(y, \mathit{poss}(x,y) \wedge \mathit{pen}(y), Q(y))$:
$[p_\sigma \multimap u_\sigma] \multimap [w_\sigma \multimap u_\sigma]$

Besides a meaning for its restriction, a determiner like *every* requires a meaning resource for its scope. When an appropriate scope meaning resource is found, it is consumed and a new meaning resource for the scope is provided, incorporating the semantics of the quantifier. Analogously, the possessive relative determiner *whose* requires a meaning resource $p_\sigma \multimap u_\sigma$, corresponding to its scope; note that we treat the scope as syntactically fixed. When this meaning is available, a meaning resource $w_\sigma \multimap u_\sigma$ for the relative clause is provided.

In the derivation of the meaning of *man whose pen Chris used*, the meaning constructors in (164) are relevant:

(164) Meaning constructors for *man whose pen Chris used*

[man] $\lambda x.\mathit{man}(x)$: $mv \multimap mr$

[wh-pen] $\lambda Q.\lambda x.\mathit{the}(y, \mathit{poss}(x,y) \wedge \mathit{pen}(y), Q(y))$:
$[p_\sigma \multimap u_\sigma] \multimap [w_\sigma \multimap u_\sigma]$

[use] $\lambda x.\lambda y.\mathit{use}(x,y)$: $c_\sigma \multimap [p_\sigma \multimap u_\sigma]$

[Chris] Chris : c_σ

[rel] $\lambda P.\lambda Q.\lambda x.P(x) \wedge Q(x)$:
$[w_\sigma \multimap u_\sigma] \multimap [[mv \multimap mr] \multimap [mv \multimap fm]]$

We begin by combining **[Chris]** and **[use]** to produce **[Chris-use]**:

(165) **[Chris-use]** $\lambda y.\mathit{use}(\mathit{Chris}, y)$: $p_\sigma \multimap u_\sigma$

This meaning constructor provides the scope resource required by **[wh-pen]**. Combining **[Chris-use]** and **[wh-pen]**, we have the meaning constructor labeled **[wh-pen-Chris-use]**:

(166) **[wh-pen-Chris-use]**
$\lambda x.\mathit{the}(y, \mathit{poss}(x,y) \wedge \mathit{pen}(y), \mathit{use}(\mathit{Chris}, y))$: $w_\sigma \multimap u_\sigma$

We can now combine **[rel]** with **[wh-pen-Chris-use]**, obtaining the meaning constructor labeled **[wh-pen-Chris-use-rel]**:

(167) **[wh-pen-Chris-see-rel]**
$\lambda Q.\lambda x.\mathit{the}(y, \mathit{poss}(x,y) \wedge \mathit{pen}(y), \mathit{use}(\mathit{Chris}, y)) \wedge Q(x)$:
$[mv \multimap mr] \multimap [mv \multimap mr]$

Combining this meaning with the meaning constructor **[man]**, we have the desired result:

(168) **[wh-pen-Chris-see-rel]**, **[man]** $\vdash$

$\lambda x.\mathit{the}(y, \mathit{poss}(x,y) \wedge \mathit{pen}(y), \mathit{use}(\mathit{Chris}, y)) \wedge \mathit{man}(x)$: $[mv \multimap mr]$

6.3. Nonrestrictive Relative Clauses

Thus far, we have examined restrictive relative clauses. These can be distinguished from nonrestrictive (or appositive) relative clauses: Arnold and Sadler (2010) review the differences between the two. Semantically, restrictive relative clauses (169) restrict the denotation of the noun which they modify, unlike nonrestrictive relative clauses (170), which simply supply additional information. In English, nonrestrictive relative clauses must be finite, and must contain a relative pronoun.

(169) Restrictive relative clause:

a. *A person [who Sandy invited] will arrive later.*

b. *A person [that Sandy invited] will arrive later.*

c. *A person [Sandy invited] will arrive later.*

(170) Nonrestrictive relative clause:

a. *Kim, who Sandy invited, will arrive later.*

b. **Kim, that Sandy invited, will arrive later.*

c. **Kim, Sandy invited, will arrive later.*

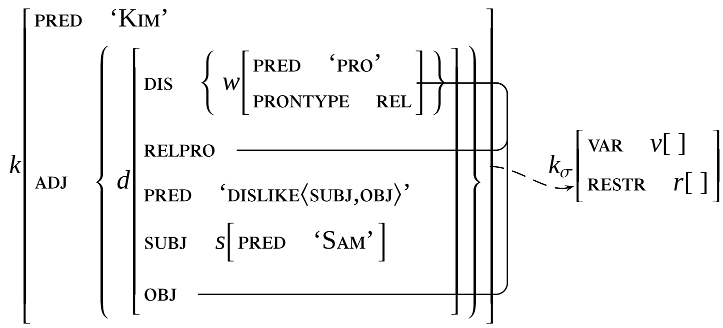
Nonrestrictive relative clauses are also associated with 'wide scope' effects. For example, as Arnold and Sadler note, example (171a), with a restrictive relative clause, entails that Kim has a belief only about linguists who use the IPA. In contrast, (171b), with a nonrestrictive relative, entails that Kim has a belief about linguists in general, and the claim that linguists use the IPA is not a part of Kim's beliefs.

(171) a. *Kim believes that linguists who use the IPA are clever.* [restrictive]

b. *Kim believes that linguists, who use the IPA, are clever.* [nonrestrictive]

Arnold and Sadler (2010) assume that restrictive and nonrestrictive relative clauses are syntactically integrated in the same way: they are both CPs adjoined at the single-bar level, forming a phrase with the head that they modify. The difference between them is rooted in their semantics. We assume the following f-structure and semantic structure for the phrase *Kim, who Sam dislikes,* which includes an appositive relative clause (ARC):

(172) *Kim, who Sam dislikes*



Arnold and Sadler (2010) base their semantic analysis of ARCs on the approach to the semantics of supplemental constructions developed by Potts (2005). As well as truth-conditional or *at-issue* content, Potts proposes another dimension comprising Gricean conventional implicatures, *ci* content. Thus, each expression is associated with a pair of meanings and a pair of types: one of the usual at-issue type, and the other of the additional *ci* type, distinguished notationally by a superscript *c* on the type specification. Potts proposes that parenthetical and supplemental/appositive constructions, including ARCs, contribute to the *ci* dimension of meaning. He analyses constructions like ARCs as involving a function *comma* which moves semantic content from the at-issue dimension to the *ci*-dimension: formally, it takes an argument of type $\langle e, t\rangle$ and returns a result of type $\langle e, t^c\rangle$, where t^c is a *ci* rather than an at-issue type. In the case of an ARC, the argument whose type is changed to *ci* content by *comma* is the relative clause. The wide scope of an ARC is accounted for under Potts's approach because *ci* content is effectively scopeless: it combines with at-issue content only at the highest level, and so the latter can never scope wider than *ci* content.

Arnold and Sadler (2010) combine Potts's approach with the analysis of relative clause semantics discussed previously in this section; their analysis derives an at-issue meaning for the relative clause, which is reclassified by the **[comma]** meaning constructor as *ci* meaning if the relative clause is nonrestrictive. They make one change to the analysis: they associate the meaning constructor **[rel]** with the CP node, rather than C′ as in (154). The rule in (173) combines the relative clause CP with the noun it modifies:

(173) N′ rule for relative clauses according to Arnold and Sadler (2010):

$$\begin{array}{cccc} \text{N}' & \longrightarrow & \text{N}' & \text{CP} \\ & & \uparrow = \downarrow & \downarrow \in (\uparrow \text{ ADJ}) \\ & & & \textbf{[rel]} \end{array}$$

This requires a slight modification of the definition of **[rel]**. Instead of the definition given in (146), Arnold and Sadler's (2010) revised definition is:

(174) Definition of **[rel]** according to Arnold and Sadler (2010):

$$\textbf{[rel]} \quad \lambda P.\lambda Q.\lambda x.P(x) \wedge Q(x) : \\ [(\downarrow \textsc{relpro})_\sigma \multimap \downarrow_\sigma] \multimap \\ [[(\uparrow_\sigma \textsc{var}) \multimap (\uparrow_\sigma \textsc{restr})] \multimap \\ [(\uparrow_\sigma \textsc{var}) \multimap (\uparrow_\sigma \textsc{restr})]]$$

Instantiating the $\uparrow$ and $\downarrow$ metavariables in (174) according to the f-structure labels in (172), we obtain the meaning constructor premise **[rel]** in (175). Like the definition given in (146), this definition has the effect of consuming the meaning of the relative clause to produce a modifier of the meaning of the head noun. For clarity, we explicitly annotate semantic structures with their types, since the distinction between at-issue and *ci* types is important. Note that all of the types in the **[rel]** meaning constructor are at-issue types.

(175) $\textbf{[rel]} \quad \lambda P.\lambda Q.\lambda x.P(x) \wedge Q(x) : [w_{\sigma\langle e\rangle} \multimap d_{\sigma\langle t\rangle}] \multimap [[v_{\langle e\rangle} \multimap r_{\langle t\rangle}] \multimap [v_{\langle e\rangle} \multimap r_{\langle t\rangle}]]$

Given this definition, the meaning of the relative clause *who Sam dislikes* (whether used restrictively or nonrestrictively) is derived from the following premises:

(176) Meaning constructors for the relative clause *who Sam dislikes*

$$\begin{array}{llcl}
\textbf{[dislike]} & \lambda x.\lambda y.\mathit{dislike}(x,y) & : & s_{\sigma\langle e\rangle} \multimap [w_{\sigma\langle e\rangle} \multimap d_{\sigma\langle t\rangle}] \\
\textbf{[Sam]} & \mathit{Sam} & : & s_{\sigma\langle e\rangle} \\
\textbf{[who]} & \lambda S.\lambda x.\mathit{person}(x) \wedge S(x) & : & [w_{\sigma\langle e\rangle} \multimap d_{\sigma\langle t\rangle}] \multimap [w_{\sigma\langle e\rangle} \multimap d_{\sigma\langle t\rangle}] \\
\textbf{[rel]} & \lambda P.\lambda Q.\lambda x.P(x) \wedge Q(x) & : & \\
 & \multicolumn{3}{r}{[w_{\sigma\langle e\rangle} \multimap d_{\sigma\langle t\rangle}] \multimap [[v_{\langle e\rangle} \multimap r_{\langle t\rangle}] \multimap [v_{\langle e\rangle} \multimap r_{\langle t\rangle}]]}
\end{array}$$

Combining these premises in the usual way, we have the meaning constructor in (177) for the relative clause:

(177) $\textbf{[dislike]}, \textbf{[Sam]}, \textbf{[who]}, \textbf{[rel]} \vdash$

$\textbf{[who-Sam-dislike]} \quad \lambda Q.\lambda x.\mathit{person}(x) \wedge \mathit{dislike}(\mathit{Sam}, x) \wedge Q(x) : [v_{\langle e\rangle} \multimap r_{\langle t\rangle}] \multimap [v_{\langle e\rangle} \multimap r_{\langle t\rangle}]$

According to Potts, in order to be interpreted as nonrestrictive, a relative clause must combine with the *comma* function, and the meaning of the relative clause is reclassified as *ci* content. In their LFG approach, Arnold and Sadler (2010) define the meaning constructor **[comma]** as in (178), with s-structure variables instantiated as in (172):

(178) $\textbf{[comma]} \quad \lambda P.\lambda y.[y, (P(\lambda z.\mathit{true}))(y)] : [[v_{\langle e\rangle} \multimap r_{\langle t\rangle}] \multimap [v_{\langle e\rangle} \multimap r_{\langle t\rangle}]] \multimap [k_{\sigma\langle e\rangle} \multimap [k_{\sigma\langle e\rangle} \otimes k_{\sigma\langle t^c\rangle}]]$

On the glue side, this meaning constructor first consumes the meaning resource of the relative clause *who Sam dislikes*, $[v \multimap r] \multimap [v \multimap r]$. On the meaning side, we apply the meaning P of the relative clause to the vacuous $[v \multimap r]$-type meaning $\lambda z.\mathit{true}$; the result, $P(\lambda z.\mathit{true})$, is a meaning of the same type, $[v \multimap r]$. We then apply this meaning to the e-type meaning corresponding to k_σ, here the meaning Kim. The result is a pair comprising an NP meaning of at-issue type e, and a propositional resource belonging to the *ci* domain $k_{\langle t^c\rangle}$. Arnold and

Sadler (2010) identify the ultimate result of combining the meaning constructors **[who-Sam-dislike]** and **[comma]** as:

(179) $[\mathit{Kim}, (\mathit{person}(\mathit{Kim}) \wedge \mathit{dislikes}(\mathit{Sam}, \mathit{Kim}) \wedge \mathit{true})] : k_{\sigma\langle e\rangle} \otimes k_{\sigma\langle t^c\rangle}$

The derivation of the at-issue content proceeds with the first element of this pair *Kim* (of type *e*), while the second, propositional, element, *dislikes*(*Sam*,*Kim*), is consumed at the highest semantic level. How this should be achieved involves a number of issues relating to resource sensitivity in LFG. Arnold and Sadler (2010) discusses some approaches; Arnold and Sadler (2011) provide a cleaner and simpler formulation.

As discussed in Chapter 8, Section 11, LFG work by, among others, Arnold and Sadler (2011) and Giorgolo and Asudeh (2011a, 2012a) has considered the analysis not only of ARCs, but also other non-at-issue, supplemental content. These proposals have implications for the analysis of meaning in LFG that go far beyond ARCs.

6.4. Resumptive Pronouns and Semantic Composition

Resumptives represent a challenge to a resource-sensitive approach to semantic composition. This is an issue explored in detail in Asudeh's (2004; 2012) work on pronominal resumption in LFG. In short, resumptives appear to represent a surplus resource. As Asudeh (2012, page 126) states, "if a resumptive pronoun is a surplus resource then the pronoun constitutes a barrier to the basic compositional requirements of the sentence in which it occurs. This would normally lead to ungrammaticality." This is the case in English, where the following is ungrammatical:

(180) **The man who Chris saw him laughed.*
(cf. *The man who Chris saw* ___ *laughed.*)

However, there are languages where the equivalent of (180) is grammatical. If a resumptive pronoun is, as Asudeh proposes following McCloskey (2002), an ordinary pronoun that makes the usual semantic contribution (see Section 1.2), what consumes the 'surplus' resource provided by the resumptive pronoun? Asudeh (2012) proposes that languages in which resumptive pronouns are grammatical have as part of their grammar additional *manager resources* which consume the surplus pronominal resource. It is the availability of the relevant manager resources, contributed by complementizers and possibly other lexical items, that determines whether resumptive pronouns are licensed in a language.

As noted in Chapter 14, Section 4, Asudeh's analysis of resumptive pronouns is based on the semantic treatment of pronouns proposed by Dalrymple et al. (1997). Though we do not adopt that proposal in this book, we describe it briefly here as a prelude to our discussion of Asudeh's theory of pronominal resumption.

Asudeh (2012) assumes that the anaphor-antecedent relation is explicitly specified by the anaphor's ANTECEDENT attribute at semantic structure. For example, in the sentence *David$_i$ thought that Chris had seen him$_i$*, where *David* is the antecedent of *him*, the semantic structure for *David* is the value of the ANTECEDENT attribute in the semantic structure of the pronoun *him*:

(181) F-structure and s-structure for *David$_i$ thought that Chris had seen him$_i$* according to Asudeh (2012), with the ANTECEDENT relation explicitly represented at s-structure:

$$
\left[\begin{array}{ll}
\text{PRED} & \text{‘THINK}\langle\text{SUBJ,COMP}\rangle\text{’}\\
\text{SUBJ} & d\left[\begin{array}{ll}\text{PRED} & \text{‘DAVID’}\end{array}\right]\\
\text{COMP} & s\left[\begin{array}{ll}
\text{PRED} & \text{‘SEE}\langle\text{SUBJ,OBJ}\rangle\text{’}\\
\text{SUBJ} & c\left[\begin{array}{ll}\text{PRED} & \text{‘CHRIS’}\end{array}\right]\\
\text{OBJ} & p\left[\begin{array}{ll}\text{PRED} & \text{‘PRO’}\\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3\\ \text{NUM} & \text{SG}\\ \text{GEND} & \text{M}\end{array}\right]\end{array}\right]
\end{array}\right]
\end{array}\right]
\quad
\begin{array}{l}
\sigma\\
d_\sigma[\ ]\\
p_\sigma\left[\text{ANTECEDENT}\quad\right]\\
\sigma
\end{array}
$$

Following Dalrymple et al. (1997), Asudeh (2012) proposes that the meaning constructor for a pronoun consumes the meaning of the pronoun's antecedent and produces it again, in the process assigning the same meaning to the pronoun. This is accomplished by the meaning constructor in (182), which consumes the meaning assignment for the antecedent and outputs a pair consisting of the antecedent meaning and the pronoun meaning.

(182) Pronoun meaning constructor according to Asudeh (2012):

him $(\uparrow\ \text{PRED}) = \text{‘PRO’}$
$\lambda x.x \times x : (\uparrow_\sigma\ \text{ANTECEDENT}) \multimap [(\uparrow_\sigma\ \text{ANTECEDENT}) \otimes \uparrow_\sigma]$

The instantiated meaning constructors for the pronoun *him* and its antecedent *David* in (181) are:

(183) **[David]** $d_\sigma : \mathit{David}$

[him] $\lambda x.x \times x : d_\sigma \multimap [d_\sigma \otimes p_\sigma]$

The meaning constructor for the pronoun consumes the meaning of its antecedent and produces a pair of resources, one for the pronoun and one for the antecedent, with the pronoun and the antecedent being assigned the same meaning. Combining **[David]** and **[him]**, we have the meaning constructor in (184), where the pronoun and its antecedent both have the meaning *David*:

(184) $\mathit{David} \times \mathit{David} : [d_\sigma \otimes p_\sigma]$

According to Asudeh (2012), languages with resumptive pronouns have manager resources which must consume a pronominal resource of the form in (182). Manager resources are of the following basic form:

(185) Manager resources (Asudeh 2012):

$$[(A \multimap A \otimes P)] \multimap (A \multimap A)$$

In (185), A is the meaning resource contributed by the antecedent. As shown in (182), the pronoun's meaning constructor can be represented as $A \multimap (A \otimes P)$, consuming the antecedent meaning A to produce a pair of resources $A \otimes P$ for the antecedent and the pronoun. The manager resource in (185) consumes the pronoun meaning constructor $A \multimap (A \otimes P)$, and produces a resource which does not include P, only $A \multimap A$. This new resource combines with the meaning resource of the antecedent A, leaving only the meaning of the antecedent A, as desired. In this way, the manager resource removes the meaning resource of the pronoun, with the result that there is no surplus resource.

Asudeh (2012) provides an analysis of the resumptive pronoun construction in Irish, illustrating with this example from McCloskey (2002, page 190). Asudeh (2012, page 186) assumes the following f-structure and semantic structure.

(186) *fir*$_i$ *an shíl Aturnae an Stáit go rabh siad*$_i$ *díleas do'n Rí*
men *aN* thought Attorney the State *go* were they loyal to.the King
'men that the Attorney General thought were loyal to the King'

$$
m\left[\begin{array}{ll}
\text{PRED} & \text{`MAN'}\\
\text{NUM} & \text{PL}\\
\text{ADJ} & \left\{ t\left[\begin{array}{ll}
\text{DIS} & a\left[\text{PRED}\ \ \text{`PRO'}\right]\\
\text{PRED} & \text{`THINK}\langle\text{SUBJ,COMP}\rangle\text{'}\\
\text{SUBJ} & g\left[\text{PRED}\ \ \text{`ATTORNEY GENERAL'}\right]\\
\text{COMP} & l\left[\begin{array}{ll}
\text{PRED} & \text{`LOYAL'}\\
\text{SUBJ} & p\left[\begin{array}{ll} \text{PRED} & \text{`PRO'}\\ \text{INDEX} & \left[\begin{array}{ll}\text{PERS} & 3\\ \text{NUM} & \text{PL}\end{array}\right]\end{array}\right]\\
\text{OBL} & k\left[\text{PRED}\ \ \text{`TO THE KING'}\right]
\end{array}\right]
\end{array}\right]\right\}
\end{array}\right]
\quad \sigma \quad
p_\sigma\left[\text{ANTECEDENT}\ \ a_\sigma[\ ]\right]
$$

A manager resource of the form in (185) is contributed by the complementizer *aN* in Irish. Crucially, the position of the resumptive pronoun is not syntactically fixed, and so Asudeh uses a local name %RP to refer to the f-structure of the resumptive pronoun, which appears somewhere within the relative clause (for more on local names, see Chapter 6, Section 5):

(187) $\%\text{RP} = (\uparrow \text{GF}^{+})$

Given this definition, Asudeh formulates the manager resource as in (188) (similar in form to the basic resource in (185):

(188) $[(\%\mathrm{RP}_\sigma\ \textsc{antecedent}) \multimap ((\%\mathrm{RP}_\sigma\ \textsc{antecedent}) \otimes \%\mathrm{RP}_\sigma)]$
$\multimap [(\%\mathrm{RP}_\sigma\ \textsc{antecedent}) \multimap (\%\mathrm{RP}_\sigma\ \textsc{antecedent})]$

The lexical entry for the complementizer *aN* (see Section 3) is revised to include the manager resource **[mr]** that it contributes.

[incomplete; to be finished]

Belyaev and Haug (2014) provide an analysis of the syntax and semantics of correlatives in Ossetic (discussed earlier in Section 1.2) which also deals with the issue of resumption, though by its nature this differs from the kind of resumption with which Asudeh (2012) is concerned. In a correlative, a subordinate clause contains a relative pronoun or phrase that is in some sense resumed by a full nominal phrase in the matrix clause. Belyaev and Haug (2014) analyze as an instance of pronominal anaphora the relationship between the relative pronoun/phrase and its correlate which appears in the matrix clause. Their LFG analysis of the semantics of Ossetic correlatives is framed in terms of Glue semantics as well as PCDRT (see Chapter 14).

7. CONSTITUENT QUESTIONS AND SEMANTIC COMPOSITION

Much current work on the semantics of questions has its roots in the work of Hamblin (1958, 1976), who shows that there is an intimate relationship between the meaning of a question and the meanings of its possible complete answers. Hamblin (1958) outlines the following postulates for the interpretation of questions:

(189) (i) An answer to a question is a statement.

(ii) Knowing what counts as an answer is equivalent to knowing the question.

(iii) The possible answers to a question are an exhaustive set of mutually exclusive possibilities.

Subsequent work by Karttunen (1977), Groenendijk and Stokhof (1984), Ginzburg (2001), Krifka (2001), Ginzburg and Sag (2000), Nelken and Francez (2002) and many others has expanded and refined our view of the semantics of questions. Useful overviews are presented by Higginbotham (1996), Ginzburg (1996), Groenendijk and Stokhof (1997) and Ginzburg (2011).

Many complications arise in the semantic analysis of questions, and a complete treatment of question semantics in a glue setting must await future research. Here we discuss some of the issues that must be addressed.

The first issue is to determine an appropriate representation of question meaning. The meaning of a question is inherently intensional, and so intensional logic provides a more appropriate way of representing question meanings than the predicate logic representations that we have assumed in previous chapters. Here as always, however, our primary focus is on semantic composition, not the details of semantic interpretation. In fact, we believe that the same issues in semantic composition arise in considering an appropriately simplified question meaning as would arise in a more complete treatment, so that a simple predicate logic meaning representation is sufficient for our present discussion. Following Ginzburg (1996), we provide the meaning in (190) for the question *Who does David like?*:

(190) *Who does David like?*

$$\lambda P.[\exists x.(\mathit{person}(x) \wedge P = \mathit{like}(\mathit{David}, x))]$$

In this expression, P represents members of the set of propositions that constitute answers to the question of who David likes: in other words, this expression picks out the set of propositions of the form $\mathit{like}(\mathit{David}, x)$ for each person x whom David likes:

(191) $$\lambda P.[\exists x.(\mathit{person}(x) \wedge P = \mathit{like}(\mathit{David}, x))] = \{\mathit{like}(\mathit{David}, \mathit{Ken}), \mathit{like}(\mathit{David}, \mathit{Mary}), \mathit{like}(\mathit{David}, \mathit{Matty}) \ldots\}$$

This simple treatment is compatible with the Hamblin postulates, since it identifies the meaning of the question with the set of propositions that constitute its complete answer.

Next, we examine the issue of semantic composition and identification of the meaning constructors that are involved in the derivation of a question meaning. The sentence *Who does David like?* has the following f-structure:

(192) *Who does David like?*

$$f\left[\begin{array}{ll} \textsc{dis} & \left\{\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{pro}\text{'}\\ \textsc{prontype} & \textsc{wh}\end{array}\right]\right\} \\ \textsc{q} & \\ \textsc{pred} & \text{`}\textsc{like}\langle\textsc{subj,obj}\rangle\text{'} \\ \textsc{subj} & \left[\begin{array}{ll}\textsc{pred} & \text{`David'}\end{array}\right] \\ \textsc{obj} & \end{array}\right]$$

A major difference between the meaning of a declarative sentence like *David likes Chris* and the meaning of the question *Who does David like?* is the type of the expressions representing their meaning. The expression in (190) is of type $\langle t \rightarrow t\rangle$: it represents a set of possible answer meanings such as $\mathit{like}(\mathit{David}, \mathit{Chris})$, each of which has the type t of a declarative sentence. Up to now, we have associated only the basic types e and t with semantic structures, not more complex types like $\langle t \rightarrow t\rangle$. We can continue to associate only basic types with semantic structures if the meaning of a question is associated not with a single semantic structure but with an implicational meaning constructor, one whose right-hand side has the form $A \multimap B$. However, we have argued in Chapter 8 that a semantically complete and coherent glue derivation results in a meaning constructor that is *not* implicational, so that some refinement to the definition of semantic completeness and coherence would need to be provided.

An alternative approach is to permit higher types such as $\langle t \rightarrow t \rangle$ to be associated with semantic structures. For example, the meaning representation in (190) is of type $\langle t \rightarrow t \rangle$, and it would be associated with the semantic structure f_σ in a full analysis of the question in (192). In that case, we must provide a theory that accounts for the discrepancy between the question type $\langle t \rightarrow t \rangle$ and the basic type t that is associated with a declarative sentence whose head is the verb *likes*. It is unclear what additional issues might arise from allowing semantic structures to be associated with higher types, though no obvious obstacles present themselves.

Finally, a desirable characteristic of any analysis of constituent questions is that it should extend unproblematically to *multiple constituent questions*: questions can contain more than one interrogative pronoun.

(193) *Who likes who?*

$$\lambda P.[\exists x.\exists y.(\mathit{person}(x) \ \wedge \mathit{person}(y) \ \wedge P = \mathit{like}(x,y))]$$

The meaning constructors that are relevant in the analysis of the question *Who does David like?* should be reusable straightforwardly and without augmentation to produce the meaning representation in (193).

The most complete discussion and analysis of the semantics of constituent questions in an LFG setting is Mycock (2006). Mycock considers a number of different approaches to the semantics of questions before adopting Ginzburg and Sag's (2000) propositional abstract approach, according to which questions are 'open propositions' that qualify as complete semantic objects in their own right. According to this unified, non-quantificational theory of the semantics of questions, each question word contributes a parameter and a place-holder. A parameter is a restriction-bearing element that links an abstracted argument to an argument role within the body of the abstract. Parameters are members of a set which takes scope over a proposition containing at least one place-holder, giving a propositional abstract. A place-holder indicates the 'gap' that a question word represents: it does not fill a semantic argument role, rather the relevant abstraction substitutes in a place-holder for a regular 'role-filler'. Under this analysis place-holders, like propositional abstracts, are themselves structured semantic objects defined in terms of other ontological entities. Mycock proposes meaning constructors for the two-fold semantic contribution of a question word (a parameter and a place-holder), along with a meaning constructor for the parameter set (of which parameters contributed by question words are members) and a meaning constructor that defines the parameter set's scope (a proposition containing at least one place-holder). Ginzburg and Sag's (2000) semantics of questions, upon which Mycock's (2006) LFG analysis is based, offers a situation semantics approach to their meaning. While situation semantics has been used to represent linguistic meaning by researchers working within LFG (for instance, Fenstad et al. 1987; Gawron and Peters 1990), a full glue approach has yet to be proposed.

In sum, the best analysis of question semantics and semantic composition in a glue setting is obtained by assuming that the meaning constructor for an interrogative pronoun like *who* combines seamlessly with the independently motivated semantic contributions of the other meaning-bearing items in the sentence to produce the desired meaning constructor, just as the meaning constructors for the relative pronoun and the relative clause combine with the other meaning constructors in the relative clause to produce an appropriate relative clause meaning constructor. It may be that some basic assumptions about meaning representations, semantic types, or other aspects of the glue approach will require some degree of modification to give an adequate account of the meanings of questions and other nondeclaratives; future research will reveal more about how these issues should be resolved.

8. FURTHER READING AND RELATED ISSUES

Much work has explored the syntactic properties of long-distance dependency constructions in LFG. In current work, as is evident from the discussion in this chapter, there is no general agreement on whether some or all long-distance dependencies involve the presence of *traces*, phonologically empty constituent structure categories that appear in the within-clause position corresponding to the displaced phrase in a long-distance dependency. Future work may help to resolve this question.

Section 1.1.1 discussed across-the-board effects in long-distance dependencies, providing a syntactic analysis; Asudeh and Crouch (2002a) revisit these effects, recasting them as a constraint on proof parallelism in a glue semantics setting.

Category mismatches or *movement paradoxes*, in which the category of a displaced constituent differs from its in-situ equivalent, were discussed briefly in Chapter 4, Section 3.3. Such constructions are not a major issue for an LFG analysis, as mismatches between different levels of structure are to be expected. Bresnan et al. (2016) analyze movement paradoxes in English, and Broadwell (2010) discusses two movement paradoxes in Zapotec.

Excluding certain grammatical functions from the path between filler and gap on a language-by-language basis to capture island constraints, as we have done in our definitions of the extraction paths for English and Tagalog, is challenged by Falk (2009). Falk observes that such an approach assumes that constraints on long-distance dependencies are “essentially arbitrary and can display infinite variation”. He proposes a different approach to the analysis of island constraints crosslinguistically, appealing to a set of features marking extraction paths, and defining islands in terms of off-path constraints. His proposal is designed to capture the extra-syntactic as well as the syntactic dimensions of island constraints in a more uniform way.

Butt et al. (2007) draw parallels between free relatives in English and German and Urdu correlatives, suggesting that the two constructions could be open to the same analysis. In earlier work, Butt et al. (1999) provide a different analysis of free relatives in English and German.

Gazdik (2011) analyses multiple questions in French and Hungarian using a level of structure that has received relatively little attention in LFG: discourse structure.

Work on constructions in other languages similar to the English *tough* construction includes Huang (1997) on Chinese, and Saiki (1990) and Yamamoto (1996) on Japanese.

Chisarik (2002) shows that split partitive noun phrases in Hungarian display properties of long-distance dependencies, and provides an analysis.

Alsina (2008) discusses multiple-gap constructions within the LFG framework, offering a different approach than the one described in Section 5. Falk (2011) considers the interaction between multiple-gap constructions and various types of islands, concluding that the former do not represent a uniform phenomenon.

Asudeh (2012) distinguishes between different types of resumptive pronouns and provides analyses that take into account the effects of processing and their relevance. He presents a processing model that incorporates LFG's approach to the grammar, defining the concept of local wellformedness in LFG-specific terms, and discusses how this captures the facts about variation in resumption (Asudeh 2012, chapter 11).

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RELATED RESEARCH THREADS AND NEW DIRECTIONS

This book has presented the theory of Lexical Functional Grammar. Part I presented the two syntactic structures of LFG, constituent structure and functional structure, and showed how they are represented, described, and constrained. Part II discussed the representation of semantic structure, information structure, prosodic structure, and the morphological module within the modular architecture of LFG, and showed how these different aspects of linguistic structure are related to one another. Part III provided syntactic and semantic analyses of a variety of linguistic phenomena, concentrating in detail on semantics and the syntax-semantics interface. Much work remains to be done on the constructions we examined, as well as on topics that have unfortunately gone unexamined in this book. In this final chapter, we turn to a brief discussion of some LFG work that has not been covered in earlier chapters.

1. PSYCHOLOGICAL REALITY: PROCESSING AND ACQUISITION

One of the original aims of LFG was to produce a *psychologically realistic* linguistic theory, one that would not only account for observed patterns of linguistic behavior but would also provide insight into the mental representation of language. Bresnan and Kaplan (1982) enumerate a list of constraints on the psycholinguistic problem of linguistic parsing, or how a speaker determines the structure of a string of words.

Creativity: The theory must account for the fact that the speaker can understand and produce entirely novel sentences.

Finite Capacity: The theory must be capable of producing an unbounded number of possible sentences from a finite number of words and rules.

Reliability: The theory must provide a nonarbitrary, reliably computable, and consistent method for deciding on the structure of a sentence.

Order-Free Composition: The theory must explain how a speaker can produce coherent analyses for arbitrary or incomplete fragments of sentences.

Universality: The theory must incorporate a universal, effective means for determining the grammar of the language that the speaker encounters.

The theory of LFG meets these desiderata. Work on psycholinguistic processing in LFG was pioneered by Ford et al. (1982), and Pinker (1982, 1989) studied issues of language acquisition in an LFG setting.

1.1. Data Oriented Parsing

The framework of *Data-Oriented Parsing* or *DOP* (Bod 1998; Bod et al. 2003) presents an alternative view of language processing and acquisition. DOP views language acquisition as the analysis of a pool of linguistic structures that are presented to the language learner. The learner breaks up these structures into their component pieces, and new utterances are assembled from these pieces. The likelihood of assigning a particular analysis to a new sentence depends on the frequency of occurrence of its component parts in the original pool of structures.

LFG-DOP (Bod and Kaplan 1998; Cormons 1999) specializes the general DOP theory to LFG assumptions about linguistic structures and the relations between them. LFG-DOP assumes that the body of linguistic evidence that a language learner is presented with consists of wellformed c-structure/f-structure pairs, and that language acquisition consists in determining the relevant component parts of these structures and then combining these parts to produce new c-structure/f-structure pairs for novel sentences. Bod and Kaplan (2003) provide an overview and describe a parser for LFG-DOP linguistic analysis; Finn et al. (2006) and Finn (2007) describe a variant approach, GF-DOP. The theory is also applied in work on translation by Way (1999, 2001, 2003), Hearne (2005), and Hearne and Way (2006).

1.2. Second Language Acquisition: Processability Theory

In combination with Levelt's model of language production (Levelt 1989; Bock and Levelt 1994; Levelt et al. 1999), LFG has been adopted as the core theoretical basis of Processability Theory (PT), a psycholinguistic theory and model of second language acquisition (SLA) first proposed by Pienemann (1998) and subsequently developed in works including Pienemann et al. (2005) and Bettoni and Di Biase (2015b). PT accounts for the acquisition of an L2 grammar in terms of developmental stages relating to universal processing procedures that form an implicational hierarchy, the *processability hierarchy*. The PT approach to SLA is thus a general one: it applies no matter what the speaker's first language (L1) and second language (L2) might be. LFG was selected to represent linguistic knowledge in PT because it is "a theory of grammar which is typologically and psychologically plausible" (Pienemann 2011, pages 37–38). Furthermore, LFG is, like Levelt's model, a lexicalist theory. For Pienemann, this commonality is crucial given that the acquisition process is most plausibly characterized as being lexically driven (Pienemann 2005b, page 18).

The PT literature covers a wide range of issues in SLA based on data from a number of different L1s and L2s, and combinations thereof, including Arabic (Mansouri 2005), Chinese (Zhang 2005), French (Ågren 2009), German (Jansen and Di Biase 2015), Italian (Di Biase and Bettoni 2015), Japanese (Kawaguchi 2015), Swedish (Glahn et al. 2001), and Russian (Artoni and Magnani 2015). Pienemann (2005a) and Bettoni and Di Biase (2015a) are significant collections of PT work. Pienemann and Keßler (2012) provides an overview of the theory; Pienemann and Keßler (2011) is an introductory textbook on PT.

1.3. LFG and Optimality Theory

Much research in phonology, morphology, syntax, and semantics has been conducted in the framework of *Optimality Theory* or *OT*. OT-based analyses assume that the grammar of a language consists of a *generator* component which proposes candidate linguistic structures for an input, and an *evaluation* component which selects the optimal structure from these candidates by reference to a ranked set of universally valid constraints on linguistic structures.

In OT-LFG, the input is taken to be an underspecified f-structure, and the generator component is a "universal" LFG grammar that generates all wellformed c-structure/f-structure pairs that are compatible with the input. The evaluation component determines the optimal candidate in a particular language from this set. Bresnan (2001b) was one of the first to combine LFG's grammatical representations with an OT-style evaluation component in an analysis of morphosyntactic blocking; Bresnan (2000) and Sells (2006a) give a useful overview of the theory. Besides the papers incorporating OT-LFG analyses which have already been mentioned in earlier chapters, and the work on diachronic syntax from an OT-LFG perspective to be described in Section 2 of this chapter, work by Broadwell (2000b, 2002, 2003, 2006), Morimoto (2000, 2001), Sells (2001b), Lee (2003, 2006), Mohanan and Mohanan (2003), Belyaev (2013), and the papers collected in Sells (2001a) are of particular note.

Important work on the formal properties of OT-LFG has also been done. Johnson (2002) discusses formal and algorithmic issues in OT-LFG parsing. Responding to issues raised by Johnson, Kuhn (2001a,b) proves that parsing in OT-LFG is decidable under certain reasonable assumptions, and resolves a number of other difficult formal issues with the theory. A clear understanding of the formal properties of generation is crucial in analyzing the formal properties of OT-LFG; the results outlined in Section 3.2 of this chapter are particularly important.

2. DIACHRONY AND CHANGE

The grammatical theory that we have presented in this book is, like other formal grammatical theories, fundamentally oriented toward synchronic grammatical analysis: it provides a framework within which a specific synchronic grammar can be modeled and analyzed, without consideration of its history or subsequent development. From a diachronic perspective, however, synchronic grammars are not isolated: the output of the grammar of one generation serves as the input to the development of the grammar of the next generation so that, at least in an approximative sense, a particular synchronic grammar can be said to have developed out of another synchronic grammar, the origins of which lie slightly further back in time, and which itself developed out of yet another, chronologically prior, synchronic grammar.[1]

The relations between different but diachronically related synchronic grammars is the realm of historical or diachronic linguistics. Diachronic changes in grammar are well studied from a descriptive perspective, but they raise certain questions for formal grammatical theories, which are primarily oriented towards synchronic analysis. The most basic question is the extent to which it is even possible to provide a descriptively adequate account of diachronic syntactic developments in a synchronically oriented formalism like LFG. Although the majority of work undertaken in LFG is exclusively synchronic in its aims, a number of authors have explored diachronic linguistic developments from an LFG perspective, and have shown that LFG is indeed adequate for representing diachronic developments. A set of important early papers are collected in Butt and King (2001). The loss of case marking and its effect on complementation and grammatical relations in Germanic and Romance languages has been explored by Allen (1995, 2008) and Vincent and Börjars (2010a); the development of verbal periphrasis, and the grammaticalization of lexical verbs into auxiliaries, is discussed by Allen (2001), Schwarze (2001b), Butt and Lahiri (2013), Lowe (2015c) and Börjars and Vincent (2016); the shift from accusative to split-ergative system in Indo-Aryan is discussed by Butt (2001a); Nikitina (2008) discusses the development of deverbal nominalizations into "mixed", i.e. partially verbal, nominalizations, and into infinitives; Börjars and Vincent (2016) discuss the development of pronouns into copulas, an instance of "lateral grammaticalization".

[1] For a detailed discussion of the nature of diachronic relations between languages at different stages, as well as the relations between grammars of those languages, see Hale (2007).

A more significant question is whether or to what extent LFG can provide an *explanatory* model of syntactic change. For example, in grammatical theories that rely on the concept of "movement" of words and constituents, the (supposed) synchronic process of movement from lexical to functional head is often invoked as an explanation for the well-attested diachronic development of lexical items into grammatical items. As discussed by Börjars (2013) and Börjars and Vincent (2016), there is no equivalent process within the LFG framework which can be so obviously invoked to explain grammatical change. However, some works have advocated the value of LFG over other grammatical theories in advancing our understanding of diachronic grammatical change, in particular Vincent (1999, 2001b), Vincent and Börjars (2010b) and Börjars and Vincent (2016). For example, Vincent (1999), Börjars et al. (2016) and Börjars and Vincent (2016) show that there is diachronic evidence for the gradual evolution of c-structure categories: a category such as P or D may develop in a language, but there may not be evidence for PP or DP; phrasal structure such as complement positions and specifier positions may develop at a later period. Such developments can be modeled in LFG, where c-structural representation is relatively free and non-projecting categories are admitted, but it challenges theories with more fixed approaches to phrase structure, where if a category P exists in a language then a full PP, including specifier and complement positions, necessarily also exists. In a similar vein, Lowe (2015b) argues that the theory of Lexical Sharing in LFG provides a means of modeling the gradual process of development between morpheme and clitic, or vice versa, which is otherwise problematic for lexicalist theories of syntax that assume an absolute distinction between word and morpheme.

A number of authors have shown that the loss of a PRED feature is a key characteristic of grammaticalization processes. Vincent (1999) shows that once a PRED feature has been lost, constraints on the synchronic system explain associated diachronic developments. That is, synchronic constraints on linguistic systems modeled in LFG by reference to the PRED feature provide an explanatory model of certain diachronic changes. The loss of PRED features in grammaticalization is also discussed by Bresnan and Mchombo (1987) and Börjars et al. (1997). Coppock and Wechsler (2010) show that the loss of person and number features is also implicated in such processes.

On some level, of course, the idea of a fixed and invariant synchronic grammar is a convenient fiction. To quote from Ohala's (1989) work on sound change, grammatical change is (at least in part) "drawn from a pool of synchronic variation". Some work in LFG has sought to model synchronic variation, which may serve as the basis of diachronic change. Bresnan et al. (2007b) make use of OT-LFG to analyze individual speaker variation and dialectal variation with respect to auxiliary-negative contractions in English. Vincent (1999, 2001a) and Vincent and Börjars (2010b) also investigate the value of combining OT with LFG to model synchronic variation as well as variation over time.

3. COMPUTATIONAL ISSUES: PARSING, GENERATION, AND IMPLEMENTATION

In an LFG computational linguistic setting, *parsing* traditionally means providing all possible c-structure/f-structure pairs for a given string of words, and *generation* means finding the strings of words that correspond to a given f-structure. As discussed in Part II, much work in LFG explores interrelated facets of linguistic structure, termed *projections*, including semantic structure, information structure, and prosodic structure. Under these assumptions, the result of parsing a string is the set of syntactic and nonsyntactic structures for a given input string and the correspondence functions that relate them. In generation, the input need not be a syntactic representation like the f-structure; semantic input can also be analyzed, and in this case generation involves determining the syntactic structures corresponding to the semantic input as well as the string that expresses that meaning.

3.1. Parsing

Much important work has been done on the theory of parsing with LFG grammars as well as on efficient parsing algorithms. A summary of work up to the mid-1990s is given by Dalrymple et al. (1995c). Significant breakthroughs have been made on several fronts.

Maxwell and Kaplan (1991) examine the problem of processing disjunctive specifications of constraints making up an f-description. Although solving nondisjunctive f-descriptions can be very efficient, processing disjunctive f-descriptions can be *exponentially difficult* when all of the disjunctions are multiplied out against each other. In other words, the time needed to process all of the disjunctive possibilities can increase exponentially as the number of disjunctions increases.[2] However, this worst-case scenario assumes that every disjunctive constraint can interact significantly with every other constraint. In linguistic processing, such interactions are found only very rarely; in fact, interactions of disjunctive constraints are almost always locally confined. For example, an ambiguity in the syntactic properties of the SUBJ of a sentence rarely correlates with ambiguities in the OBJ or other arguments. This insight is the basis of Maxwell and Kaplan's algorithm, which works by turning a set of disjunctively specified constraints into a set of *contexted*, conjunctively specified constraints, where the context of a constraint indicates how the constraint fits into the configuration of disjunctions. Solving these contexted constraints turns out to be very efficient for linguistically motivated sets of constraints, where only local interactions among disjunctions tend to occur.

[2] An exponential increase can be thought of in terms of some constant number raised to the *n*th power, where *n* is the number of constraints. To give a rough idea of the rate of increase in complexity as the number of constraints grows, if solving one constraint takes $2^1 = 2$ seconds, solving three constraints could take $2^3 = 8$ seconds, and solving fifteen constraints could take $2^{15} = 32,768$ seconds or about 9 hours.

The second breakthrough was made by Maxwell and Kaplan (1993), who explore the issue of c-structure processing and its relation to solving f-structural constraints. As observed in Chapter 7, Section 6, phrase structure trees provide a clear and perspicuous representation of dominance and precedence conditions and phrasal structure and groupings, while functional structures are an appropriate representation for grammatical functions and features. However, it has long been known that constituent structure parsing — determining the phrase structure trees for a given sentence — is very fast in comparison to solving the disjunctions of equations that determine the f-structure for the sentence: parsing with a context-free phrase structure grammar[3] to produce a c-structure can be accomplished in *cubic time*,[4] in contrast to the potentially exponential problem of determining the corresponding f-structures. For this reason, an important task in designing algorithms for linguistic processing of structures of formally different kinds, like the c-structure and the f-structure, is to optimize the interactions between these computationally very different tasks. Previous research often assumed that the most efficient approach would be to interleave the construction of the phrase structure tree with the solution of f-structure constraints. Maxwell and Kaplan (1993) explore and compare a number of different methods for combining phrase structure processing with constraint solving; they show that in certain situations, interleaving the two processes can actually give very bad results.

The third breakthrough built on these findings: Maxwell and Kaplan (1996) showed that if phrase structure parsing and f-structural constraint solving are combined in the right way, parsing can be very fast in many cases. Although the worst case scenario involving complex interactions among constraints is still exponential, the linguistically more common situation is for interactions among constraints to be limited. In such cases, if the grammar that results from combining phrase structure and functional constraints happens to be *context-free equivalent*, the algorithm for computing the c-structure and f-structure operates in cubic time, the same as for pure phrase structure parsing.

In ongoing unpublished work, Ron Kaplan and Jürgen Wedekind explore the question of whether the linguistically-relevant subset of the LFG formalism – the constructs that seem to be necessary and exploited in real grammars – may

[3]The formal properties of context-free languages and their grammars, context-free grammars, are described in Partee et al. (1993, Chapter 16). The added expressivity gained by allowing regular expressions on the right-hand side of phrase structure rules, including the Kleene star, does not take us beyond the power of context-free languages, as demonstrated by Woods (1970).

[4]Parsing in cubic time is a particular instance of a problem that can be solved in polynomial time. If a problem can be solved in polynomial time, the time it takes to solve a problem of size n is n raised to some constant power; in the case of cubic time parsing, that constant is 3. Thus, if parsing complexity depends on the length of the sentence we are parsing and a sentence of one word can be parsed in $1^3 = 1$ second, a sentence consisting of three words would be parsed in $3^3 = 27$ seconds, and a sentence with fifteen words would be parsed in $15^3 = 3,375$ seconds, or about 56 minutes. Of course, actual parsing times are much faster than this for both short and long sentences: these figures are merely intended to illustrate the rate of growth of a polynomial problem as opposed to an exponential problem. Parsing in cubic time is much quicker and more efficient than the exponential growth associated with solving arbitrary sets of functional constraints.

be translatable into a weaker formal system, *multiple context-free grammars* (Pollard 1984; Seki et al. 1991). The interest of this possibility lies in the fact that grammars in this class can be parsed in polynomial time, guaranteeing the best-case polynomial result of Maxwell and Kaplan (1996) for all grammars. Further research will show whether these interesting speculations will bear fruit.

3.2. Generation

Work on generation in LFG generally assumes that the generation task is to determine the strings of a language that correspond to a specified f-structure, given a particular grammar. Based on these assumptions, several interesting theoretical results have been attained; Wedekind (2006) provides a useful overview, and Butt et al. (2006, Part I) includes several papers describing LFG-based work on generation and translation.

Wedekind (1995, 1999, 2014) addresses the issue of the decidability of generation from f-structures: the problem of determining whether there is any sentence that corresponds to a given f-structure according to a given grammar. Wedekind (1995) demonstrates that the problem is decidable for *fully specified, acyclic*[5] f-structures: if we assume that the f-structure we are given is complete, has no cycles, and no additional features can be added, we can always determine whether or not there is a sentence that corresponds to that f-structure. Wedekind (1999) shows that the corresponding problem for *underspecified* f-structures is not decidable: it is not always possible to determine whether there is a sentence that corresponds to a given f-structure if we are allowed to add additional attributes and values to the f-structure. Wedekind (2014) demonstrates that the corresponding problem for *cyclic* f-structures is not decidable, even when the f-structure is fully specified: it is not always possible to determine whether there is a sentence that corresponds to a given f-structure if it contains one or more cycles.

In further work on the formal properties of generation from f-structures, Kaplan and Wedekind (2000) show that if we are given an LFG grammar and an acyclic f-structure, the set of strings that corresponds to that f-structure according to the grammar is a *context-free language*. Building on and extending that work, Wedekind and Kaplan (2012) provide a method for constructing the context-free grammar for that set of strings by a process of specialization of the full grammar that we are given. This result leads to a new way of thinking about generation; opens the way to new, more efficient generation algorithms; and clarifies a number of formal and mathematical issues relating to LFG parsing and generation.

Wedekind and Kaplan (1996) explore issues in *ambiguity-preserving generation*, where a set of f-structures rather than a single f-structure is considered, and the sentences of interest are those that correspond to all of the f-structures under consideration; Shemtov (1997) also explores issues in ambiguity management and ambiguity preservation in generation from sets of f-structures. The poten-

[5] An *acyclic* f-structure is one in which no f-structure contains a path leading back to itself. Kaplan and Bresnan (1982) suggest that acyclic structures are the only f-structures that are motivated for linguistic analysis.

tial practical advantages of ambiguity-preserving generation are clear: consider, for example, a scenario involving translation from English to German. We first parse the input English sentence, producing several f-structures if the English sentence is ambiguous. For instance, the English sentence *Hans saw the man with the telescope* is ambiguous: it means either that the man had the telescope or that Hans used the telescope to see the man. The best translation for this sentence would be a German sentence that is ambiguous in exactly the same way as the English sentence, if such a German sentence exists; in the case at hand, we would like to produce the German sentence *Hans sah den Mann mit dem Fernrohr*, which has exactly the same two meanings as the English input. To do this, we map the English f-structures for the input sentence to the set of corresponding German f-structures; our goal is then to generate the German sentence *Hans sah den Mann mit dem Fernrohr*, which corresponds to each of these f-structures. Though this approach is appealing, Wedekind and Kaplan (1996) show that determining whether there is a single sentence that corresponds to each member of a set of f-structures is in general *undecidable* for an arbitrary (possibly linguistically unreasonable) LFG grammar: there are LFG grammars and sets of f-structures for which it is impossible to determine whether there is any sentence that corresponds to those f-structures. This result is important in understanding the limits of ambiguity-preserving generation.

3.3. LFG-Based Grammar Development Platforms

The important algorithmic results on parsing and generation described above have enabled the development of computational implementations of LFG grammars and grammar development platforms supporting analysis and generation with LFG grammars. One of the earliest LFG implementations was the Grammar Writer's Workbench (Kaplan and Maxwell 1996), originally implemented in the early 1980s in the Xerox Interlisp-D environment, and under development through the mid-1990s at the Xerox Palo Alto Research Center (PARC). In 1993, the PARC team undertook a new implementation in C; this became the Xerox Linguistic Environment (XLE: Crouch et al. 2008; Maxwell 2015). The XLE underpins a number of large-scale grammar implementations within the PARGRAM project (Section 3.4). More recently, Lionel Clément and his colleagues have developed xLFG, a web-based LFG parsing platform (Clément and Kinyon 2001; Clément 2016), and Damir Cavar is leading a team to produce a freely available grammar development platform for LFG and related grammar formalisms, the Free Linguistic Environment (`http://gorilla.linguistlist.org/fle/`).

The availability of computational implementations of LFG, and in particular the XLE, has enabled research on combining LFG grammars with other computational tools to increase parsing efficiency, improve parsing results, or produce more useful language-based applications. Kaplan and King (2003) experiment with tools which augment the input to the parsing process with various kinds of additional information: using a finite-state parser to bracket the input string to indicate the presence of phrasal boundaries, using a tagger to add part-of-speech annotations to the words in the input, and using a gazetteer or onomasticon to mark word sequences as the name of a person, place, or company. For example, the unannotated string in (1a) might be annotated as in (1b) for input to XLE processing:

(1) a. *New York City is a nice place to live.*
    b. *<city>New York City</city> is [*$_{\text{NP}}$ *a nice*$_{\text{A}}$ *place*$_{\text{N}}$ *to live*$_{\text{V}}$*].*

Such information is useful in reducing ambiguity and increasing efficiency when it is completely accurate, but this is very dependent on the tools which are used to add this information; such tools are often prone to error. Kaplan and King found that adding information about known sequences such as *New York City* and information about phrasal boundaries tended to be helpful, but that the addition of part-of-speech information tended not to be very useful. Of course, these results are entirely dependent on the particular tools that provide these annotations and how compatible they are with the LFG grammar that is used. Kaplan et al. (2004) provide further discussion of such annotations, and also provide an overview of the use of *finite state transducers* for morphological analysis in parsing and generation (Kaplan and Kay 1994; Beesley and Karttunen 2003) and their incorporation into the XLE environment. In other work, Riezler et al. (2002) show that a stochastic disambiguation model can be combined with a broad-coverage LFG grammar to improve accuracy in choosing among different parses for the same sentence.

Implementations have also been developed which add a semantic component to LFG systems or permit compositional semantic analyses in an LFG setting. The XLE system includes a transfer component, XFR (Maxwell 2017), which allows f-structures to be rewritten into other representations by means of a set of transfer rules. The XFR component was originally intended for use as part of a machine translation system, but has also been used to rewrite f-structures into semantic structures, as described by Crouch and King (2006). Theorem provers for glue semantics have been developed by Giorgolo (2017), including a standalone prover as well as the “glue-xle” system, which can be used together with XLE.

3.4. The PARGRAM Project

The Parallel Grammar Project (PARGRAM: Butt et al. 1999, Butt et al. 2002b) was founded in 1994 as a research consortium to write large-scale, parallel LFG grammars using the XLE grammar development platform. The grammars are “parallel” in the sense that they are developed under a common set of grammatical assumptions, using a commonly agreed on set of grammatical features; differences among the grammars are due to differences among the grammars of the languages of the project, not different theoretical stances or arbitrary analytical decisions on the part of the grammar writers. In 1994, the project included only grammars of English (developed at PARC), French (developed at the Rank

Xerox Research Centre in Grenoble), and German (developed at the Institute for Natural Language Processing, University of Stuttgart), but the project later grew to include, at various times, grammars of Norwegian, Japanese, Urdu, Turkish, Hungarian, Georgian, Tigrinya, Wolof, Indonesian, Welsh, Malagasy, Chinese, Arabic, Vietnamese, Polish, and Northern Soto. Besides an in-depth understanding of these languages and their grammars, the project has produced practical resources that have been used in various computational applications, including automatic machine translation, summarization, and question answering. The English grammar formed the core of the natural language search engine built by Powerset, a company started in 2006 which was acquired by Microsoft in 2008, and has influenced the development of the Bing search engine.

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In most cases, language families are listed according to the classifications given in the World Atlas of Linguistic Structures (WALS: Haspelmath et al. 2008). Information on where languages are spoken is often only approximate; see the WALS database for full details.

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